Delhi's Water and Solid Waste Management
Emerging Scenario

Environmental Hotspots

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VIGYAN PRASAR

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Delhi's Water and Solid Waste Management : Emerging Scenario

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Foreword

It would be a gross understatement to say that India is besieged with problems of environment. Most of our big, medium and small towns and cities are becoming more unlivable for humans with every passing day not with standing a good bit of public interest litigation, an activist judiciary, the human rights commission, and the fact that a large part of our urban population in all major cities and bigger towns inhabits slums under inhuman, unsanitary and intolerable conditions.

Why, in the midst of all this, talk about "India's top environmental hotspots?" You would indeed be right in wondering why! For, each problem is worse than the other in terms of severity and chances of it getting resolved or overcome without a whole lot of things happening and many an actor getting their act together ?

That's precisely why! Vigyan Prasar does not have solutions to those problems. (No one else does either!) Through these reports, we would like more and more people to become aware of each of these problems in a way which would allow them to take a more dispassionate and objective view of the real issues involved, of the contentions being made by the proponents as well as the opponents; of whether the hard data available are, or are not sufficient to back up or support contentions on either side of the divide, or to clinch any issues decisively in favour of one view or the other; and so on and form their own informed opinions on such issues, as also be able to query proponents/opponents on specific points.

Accordingly, for each selected hotspot, we have attempted to present at one place all the relevant facts, data and information available; the contentious issues involved alongwith the stated positions (on each of these issues) of the proponents and opponents and a bibliography listing references, sources of information and other materials available for more details and further reading.

We at Vigyan Prasar felt that while such contentious issues get a great deal of coverage in the mass media (print, radio & television), especially during public campaigns launched by the opponents, and common people become aware of these controversies, they hardly know anything about the key issues involved, or of their background and are unable to formulate their own stands for lack of ready access to the required information. Hence, these reports! We also intend bringing out language versions of these reports depending on the response they evoke and the feedback they generate.

While bringing out these reports we are conscious of the fact that there is a plethora of information available on most of the topics, but spread out at hundreds of places. In fact in some cases the enormity of diverse materials available comes in the way of getting at the desired information. Particularly those who are not following the events find themselves at a loss. These reports are not intended to oppose or to support any existing view points on a particular topic. Nor should one expect any fresh insight or inputs—other than seeing all the essential things at one place. While putting together the relevant material if something has been left out, in spite of our sincere and conscious efforts, it should not be construed as intentional. We would be happy to see someone pointing out such an omission and we would try correcting it immediately.

We would welcome critical comments and observations on these reports and love to receive inputs/suggestions on further topics need to include under this series.

Narender K. Sehgal
Director
Vigyan Prasar

September 1998

VIGYAN PRASAR
An Introduction

Vigyan Prasar (VP) was set up by the Department of Science and Technology, Government of India, as an autonomous registered Society in 1989 for taking up large-scale science popularisation tasks. Its broad objectives may be summarised as follows:

To undertake, aid, promote, guide and co-ordinate efforts in popularisation of science and inculcation of scientific temper among the people and to increase the knowledge, awareness and interest about science and technology among all segments of the society.

To provide and promote effective linkages on a continuing basis among various scientific institutions, agencies, educational and academic bodies, laboratories, museums, industry, trade and other organisations for effective exchange and dissemination of S&T information.

To undertake development of materials—audio, visual, audio-visual and printed—methods and modes of communication, so as to enable the masses to better understand, appreciate and comprehend abstract scientific principles and practices.

To organise research work, courses, workshops, seminars, symposia, training programmes, fairs, exhibitions, film-shows, popular discussions, street plays, quizzes, song-dance-dramas etc., in furtherance of the objectives of the Society.

After its establishment Vigyan Prasar remained dormant for a few years. Only in 1994 some activities could be taken up in right earnest. One among the first few programmes initiated by Vigyan Prasar was the 'Ready-to-Print' Science Page project. The idea was to prepare a well laid-out newspaper-size page with one or two features and several smaller items on scientific and technological (S&T) developments taking place in India, appropriately supported with photographs, illustrations, graphics etc., and to supply it to newspapers to carry as it is. Initially, such pages in Hindi and English

were planned for release once a month. Subsequently, a children's page, science pages in other major Indian languages and a feature packet service were also added. Today, these pages are being carried once or twice a month by more than 30 editions of some 20 newspapers spread all over the country. In fact, today Vigyan Prasar's are the largest circulated science pages in the country. The combined print order of all these newspapers exceeds 2.5 million copies. These pages have led to fresh demands for enhanced science coverage in other newspapers.

Vigyan Prasar's publications programme is gradually taking the shape. A number of important series has been launched; some more are planned. The first major English publication brought out by Vigyan Prasar, viz., *"Memoirs of Ruchi Ram Sahni: Pioneer of Science Popularisation in Punjab."* Under its series on Pioneer Science Popularisers in Pre-Independence India has generated positive awareness among science communicators and enthused researchers about the need to unearth other such personalities in other parts of the country. Already names of a number of individuals who did pioneering work in the field of science popularisation in pre-Independence India have come to light.

Popular science classics written by Great Masters in the past, which have inspired generations of students of science, are no longer seen in the hands of our younger generation. This is not because these books have gone out of context, but because they are no longer available. Vigyan Prasar under its Popular Science Classics series intends to reprint these books and bring them out in low-priced affordable editions so that more and more children can have them. Already two such classics (Michael Faraday's *Chemical History of a Candle* and C.V. Boy's *Soap Bubbles And the Forces Which Mould Them)* and their different language versions viz., Marathi, Tamil and Hindi have also been brought out. George Gamow's "One,Two, Three...Infinity: Facts and Speculations of Science" has also been translated into Hindi.

Inspired by the focal theme for the National Science Day-1995, viz., 'Science for Health', Vigyan Prasar initiated a Health Series. Under it's publications on all common diseases, along with

possible management of their curative and preventive aspects would be brought out. The first three titles on *Sexually Transmitted Diseases, Asthma and Jaundice,* have already been released. More titles including books in other languages are also coming out.

Under its series of Monographs on India's Scientific Heritage Vigyan Prasar intends to bring out publications on specific science and technology areas in which India's contributions have stood the test of time, as also have made an impact on modern-day science. The first monograph in the series, *'The Rustless Wonder: A Study of the Iron Pillar at Delhi'* was released on 30 January 1997. The second volume *'Where Gods Come Alive: A Study of the South Indian Bronze Icons '* is in the press and would come out shortly.

Some of the other publications brought out by Vigyan Prasar are *My Friend Mr Leakey, & Everything Has a History* by J.B.S. Haldane; *Development and Valuation of Urban Properties*, by P.K. Ratho, *Alternatives to Pesticides in Tropical Countries* by A.T. Dudani.

A new series on Environmental Hotspots was launched by Vigyan Prasar recently.The first volume brought out under the series is on Tehri Hydro-Electric Project and Narmada Valley Project. Total Solar Eclipse of October 24, 1995, provided Vigyan Prasar a rare opportunity to organise a country-wide awareness campaign, aimed at dispelling age-old myths and superstitious beliefs related to eclipses, and to develop among people an urge to learn about their known scientific aspects. Vigyan Prasar jointly with the National Council for Science and Technology Communication (NCSTC) organised a number of activities:

i. Telescope-making workshops for students and teachers.

ii. Development and production of books, a total solar eclipse chart and an activity kit for children.

iii. Production of several video films and their telecast.

Vigyan Prasar conceptualised and implemented a novel idea for ensuring that people did come out and watch the total solar eclipse. It circulated a total solar eclipse pledge. People in thousands from all corners of the country sent in signed pledges. Many individuals and

voluntary agencies got these pledges translated into regional languages on their own and distributed the same in large numbers. All these led to a chain of activities throughout the country. The efforts made by VP, NCSTC and other agencies created a situation where millions of people came out and watched the spectacular event. This was a unique experience and made Vigyan Prasar's name a household word throughout the country.

Under its audio-visual programme, Vigyan Prasar developed a set of video films and several radio programmes on the occasion of the total solar eclipse of 24 October, 1995. This event-based effort was enormously satisfying for the VP family and generated a very good response from the public at large.

Vigyan Prasar has recently begun building an Information System called VIPRIS — acronym for **VI**gyan **PR**asar **I**nformation **S**ystem — to meet a long-standing demand from different quarters, particularly the science communicators, to establish a repository of background data and information on various aspects of S&T which would be accessible easily. The computerised system would be built on a modular basis, and aim to meet the information needs of science communicators of all kinds.

At this stage, under VIPRIS, we have a fortnightly clippings service, an electronic Bulletin Board Service (BBS), weekly science news on the radio, and had two pages daily on Doordarshan's teletext service till it was closed and several other products and services including training, generation of data bases on different subject areas etc., in the making.

The first phase of the database on " Environment & Safety Laws: Regulations & Guidance Documents " has been completed. VP launched its Homepage on the Internet on 12 September, 1996. An online electronic popular science magazine 'ComCom', was launched soon after as part of the Homepage. The other sections of the Homepage are, About Vigyan Prasar, Daily Weather Report, Sky map of the days/month, links with other related homepage, S&T vacancies in India, News from S&T laboratories, S&T databases etc. It has provision for Hindi HTML and support for Web browsers / users to download the Hindi Plug-in and install it in their

system. It has also a discussion forum with support to display and keep visitors' views.

Taking note of the growing popularity of the mulimedia mode of presentation Vigyan Prasar has launched a programme to bring out CD-ROMs on different aspects of S&T. The first two CD-ROMs, are based on its recent publications viz., The Rustless Wonder: A study of the Iron Pillar at Delhi" and "Mad, Mad, Mad Cow: An Overview of the Mad Cow Disease". The other two CD-ROMs under development are on 'Eclipses' and 'Living Space and Structures'.

A number of video programmes has also been produced. Recent ones among them have been on "Herbal Petrol" and "Comets" (in connection with the coming of the comet "Hale-Bopp"). Several other programmes are under production.

Vigyan Prasar and All India Radio, Bhopal jointly produced "Paryavaran Calling", a 26-part fortnightly phone-in-quiz radio serial. This programme was aimed at inculcating scientific attitude and awareness about all aspects of environment among the masses. The phone-in as well as postal winners were taken on a Nature Tour of 2-3 day's duration to tourist and environmentally important places of Madhya Pradesh. Similar kinds of programmes are to be launched with All India Radio, Chennai and Guwahati.

Vigyan Prasar has also produced audio-cassette sets of the 108-part radio serial 'Manav Ka Vikas' (jointly produced by the NCSTC and All India Radio) in 18 Indian languages.

Vigyan Prasar has initiated programme to establish science clubs in different parts of the country under the aegis of VIPNET. Efforts are also on to popularise HAM-Radio

This is not all. Vigyan Prasar does many other things. But for now this should suffice.

Narender K. Sehgal
Director
Vigyan Prasar

Part - I
Delhi's Water : Emerging Scenario

S. K. Rohilla & P. S. Datta

Views expressed are that of the authors and not of the organisations they represent.

Summary

Delhi faces an acute water crisis in every summer. A varying degree of inadequacy of water is, however, felt around the year. This has led to the over-exploitation of groundwater and nearly drying up of the river Yamuna.

The current demand for water in National Capital Territory (NCT) Delhi is 770 mgd and the projected demand in 2001 AD is 1024 mgd according to the Delhi Development Authority (DDA). This demand projection is only for urban areas and excludes the agricultural demand and rural domestic demand. Presently, the supply from Delhi Jal Board sources is 600 mgd and no additional raw water supplies are on the horizon. The population of the NCT Delhi is projected to be 128 lakhs in year 2001 as per DDA's Master Plan Delhi (MPD) - 2001. Thus, while the demand will expand dramatically, the supply position is not so elastic.

All planning for future water supply in Delhi is based upon anticipated additional raw water inflow from three large dams under construction in the Himalayas. These are the Tehri Dam in Uttar Pradesh (U.P.), Kishau Dam & Renuka Dam in Himachal Pradesh (H.P.). While Tehri's progress is bogged down in environmental controversies work on the other two dams has yet to take off. Even if these two dams overcome environmental imbroglios and acute financial constraints and the work commences immediately they would not be able to supply any water for another 15 years. By then, the rapidly growing population of Delhi would become unsustainable, its ground-water perhaps exhausted or severely polluted. The unfolding scenario is grim. This should serve to alert the city administration to make further planning and development activity completely subservient to environmental considerations.

Introduction

Ever since the time of the eminent Greek philosopher, Aristotle, concerns have been continuously expressed about enough water resources being available for human consumption for future generations. Delhi is no exception. Throughout every year different parts of Delhi face water scarcity. The problem becomes acute during summer when water demand for different purposes increases dramatically. This problem is likely to aggravate further with rapid growth in population which may become unsustainable with further deterioration of the eco-system. This could result in a multidimensional crisis in the National Capital Territory. In fact in some parts the signs of such a grim scenario have already creeped in. It has become a matter of concern for the planners and decision makers to search for an alternative approach for water management subservient to environmental considerations.

2.0 Study Area Profile

The Delhi region is a part of the Indo-Gangetic Alluvial Plains at an elevation ranging from 198 to 220m above msl, with an area of 1483 sq.km. The area lies between 28°23'17"N- 28°53'00"N and 76°50'24"E-77°20'37E.

2.1 Climate and Soils

The climate of the region is semi-arid. The area is located in the 'monsoon trough' and experiences 'monsoon depressions' which are characterised by heavy rainfall events. The average annual rainfall (1931-91) is 611 mm, most of which falls between June and September. The average annual evaporation is about 2540 mm in Delhi. The mean minimum and maximum temperatures are 18.7°C and 30.5°C respectively. During the hottest months of May and June, temperature commonly exceeds 40°C.

2.2 Physiography and Geology

Almost flat plains exist extensively throughout the region, transacted by

a rocky ridge in the south-eastern part. The ridge has a maximum elevation of 306.63m above msl in the south-eastern part of the area and rises about 15 to 91 m above the surrounding plains. The ridge forms the principal watershed of the area and acts as a groundwater divide between the western and eastern parts of Delhi area. To the east of the ridge, the drainage flows into the river Yamuna and to the west of it, the south-central part of Najafgarh block receives the surface run-off of the area.

2.3 Settlement Pattern and Population

Of the total area of 1483 sq.km., 685 sq.km (46%) is urban and 798 sq.km (54%) is rural. On the basis of projected urbanisation by the year 2001 the position will change to about 57% urban and 43% rural area. East and west of the river Yamuna are highly urbanised and form the urban core, which includes 111 urban villages. The outlying areas consist of 258 villages some of which are large enough to be classified as census towns. There is a proposal for developing 15 Growth Centres and 33 Growth Points for rural areas. Each village earmarked as Growth Centre shall serve as a mini town. Delhi Development Authority (DDA) also plans to develop three sub-cities namely Dwarka (to accommodate 12 lakhs), Narela (14 lakhs), Dhirpur (0.4 lakhs) and another 8 lakhs in Rohini extension almost 34 to 35 lakh population to be accommodated by 2005 AD in NCT Delhi.

As per the 1991 census, NCT Delhi has a total population of 9,420,644 of which about 90 % (8,471,625) is urban and the rest about 10% (949,019) is rural.

3.0 Statement of the Problem - Background

3.1 Historical

The earliest known capital city of Delhi was called Indraprastha. In the great epic Mahabharata, Rishi Narada greeted the great Pandava King Yudhishtira with the following words : "I hope your realm has reservoirs that are large and full of water, located in different parts of the land so that the agriculture does not depend on the caprice of the Rain God". The other cities with their names and years of establishment are listed chronologically with their water supply systems :

Year (AD)	Name of the city	Water Supply Systems
972-1150	Lal Kot-Qila Rai Pithora	Regular system of water supply through dams and tanks e.g. Anangtal & Surajkund
1191-1290	Mehrauli	Elaborate water harvesting system e.g. Hauz-a-Shamsi the Jharna, Stepwells - Rajon Ki Boali & Gandhak Ki Boali
1296-1320	Siri	Hauz Khas (Huaz-i-Alai) the vast reservoir to meet the water requirements
1321-1334	Tuglakabad	On south side, a vast reservoir was created for harvesting rainwater for the city, also there were 7 water tanks for drinking water.
1334-1351	Jahanpanah	Satpula dam/reservoir to harvest and regulate rain water for irrigation purpose & water tanks for drinking water.
1351-1388	Firozabad	Located on the bank of river Yamuna. Well watered. For the first time, Yamuna canal was constructed to irrigate. Also had a Baoli (tank).
1530-1540	Dinpanah	Located on the western bank of river Yamuna. Ugrasen Ki Baoli is a remarkable water harvesting structure of this period.
1638-1648	Shahajahanabad	Located on the western banks of river Yamuna, had immaculate and novel arrangements for water supply to city through canal system laid linking Yamuna river to fulfill the need of water
1931	New Delhi	Western Yamuna Canal

(* ***Source*** *: A.K. Jain "The Seven Cities of Delhi")*

One of the major factors which govern the founding of these cities was existence of river or the vicinity of a water body. With the changing course of the Yamuna or floods in Yamuna or scarcity of water the shifting or rebuilding of Delhi city took place time and again. Due to the shortage of water in Mehrauli, Ferozshah moved his capital to new city called Ferozabad (Ferozabad Kotla) along the river Yamuna. Tuglakabad was deserted because of a shortage of water.

3.2 Pre-independence

To provide drinking water to old city the Ali Mardan canal was lined and reopened. The census of year 1843 recorded a population of 1.31 lacs. In the same year water sources were surveyed and providing drinking water from the river was considered necessary. In year 1892 a waterworks was opened in Delhi which introduced piped water supply in the buildings. The total yield of water in 1891 was 0.6 mgd. In year 1895 the construction of a sewer in the Chandni Chowk area was undertaken. With the provision of settling tanks and filters the availability of potable water rose to about 1.7 mgd for a population of 2 lacs. The Delhi Joint Water and Sewage Board was set up in 1926 for managing water supply and sewage disposal. The production was steadily increased, and, by 1946 it reached 30 mgd.

3.3 Post-independence

In 1947, with partition, Delhi saw a large influx of refugee population and the city grew haphazardly in all directions. This started a new chapter in the growth of Delhi. After the formation of Delhi Development Authority (DDA) in 1957, a 20-year masterplan was finally approved in 1962. It proposed enlarging the existing urban area of 18,000 ha. to 44,736 ha. The development of Delhi on a massive scale and the centralisation of resources, induced the development of towns on the periphery of Delhi like Ghaziabad, Noida, Gurgoan, Sonepat etc. Their development failed to deflect population from Delhi and created more pressure on its basic services like water supply.

In 1958, when Delhi Water Supply and Sewage Disposal Undertaking; predecessor of the Delhi Jal Board was set up, the population of Delhi was 2.4 million and the production of water was 97 mgd. In 1959 a barrage was constructed near Wazirabad in Delhi, across the Yamuna river to provide additional storage capacity. Subsequently,

additional intake work, a treatment plant at Okhla in South Delhi, Ranney wells in Shahdara (trans-Yamuna) and tubewells were added in South and West Delhi, to meet the rapidly growing demand.

Delhi is dependent for raw water from distant sources of water supply. During the last 40 years, with phenomenal growth in population and continuing influx of population @5 to 6 lac people per year. Today the population of Delhi is estimated to be 12.8 million, while the availability of water is only 600 mgd leaving an uncovered gap of 170 mgd between the demand and supply for water. The population growth has not been matched by a proportionate increase in the raw water availability. Things have worsened over the last decade or so with the public demanding a regular supply even if it is for an hour or two a day. This is further compounded by the skewed distribution of water, low supply pressure and risk of contamination from the old corroded pipes. The mushrooming growth of population pockets in slum & J.J. Clusters and unauthorised colonies without infrastructure has further stretched the water supply system in the city.

All the ancient city sites of Delhi, including New Delhi, were located within the triangle formed by the northern ridge, the southern ridge and the river Yamuna - a very strategic location. The capital city today engulfed all the ancient city sites and overflows across the river Yamuna and the northern ridge. In the past Delhi's landscape was modified through the process of settlement, irrigation, cultivation and planting, through judicious management of the surrounding natural resources. The Mughals managed the available water resources to derive maximum advantage. The British tried to moderate the climate through foliage and planting. The exploitation of natural resources was always balanced with regenerative capacity. However, once picturesque and admired for its bountiful water, lush green belt, forests and agricultural areas, over the years Lutyen's Garden City and entire NCT Delhi is facing water scarcity due to urban sprawling in the adjoining green belt, declining supply of water and degradation of the in-situ natural resource base-(depletion of ground water).

4.0 Population and Slums : Growth and Projections

The city's environment appears to have degraded, primarily because of fast rising population (Fig.1), expanding industrialisation, haphazard landuse, inadequate civic facilities and poor public response to the need for environmental protection. From a population of barely 4 lacs in 1901, it increased to 17.44 lacs in 1951; 62.20 lacs in 1981; 94.20 lacs in 1991 and 108.4 lacs in 1996. It is estimated that by the turn of the century the population would cross 130 lacs. According to the 1991 census, the population density is 6352 per sq.km., the highest among all the states and Union Territories of India.

Immigration has been a major cause of Delhi's rapid growth. During the decade 1961-71, 5.3 lakhs people migrated to Delhi, by 1971-81 it increased to 12.3 lakhs. During 1981-91, it was estimated at 20 lakhs. The neighbouring states of Uttar Pradesh, Haryana and Rajasthan account for over 70% of the migration. Of Delhi's housing stock, over two-thirds are attributed to squatters/unauthorised settlements/ slums. The number of such units increased by 50% during the last decade. There are 600 unauthorised/non-regularised colonies and about 800 jhuggi clusters which as per official policy have to be provided with regular water supply. The number of squatters in Delhi has increased five fold during 1961-1990 from 43,000 to 2,40,000.

Demand and Supply of Water in NCT Delhi*

	Years			
	1991	**1998**	**2001**	**2005**
Demand (in mld)	2973(654)	4303(948)	4791(1005)	5227(1151)
Supply (in mld)	2143(412)	2724(600)	no additional raw water likely to be available	
Gap (in mld)	830(183)	1580(348)	2067(455)	2503(551)

(**Source*: *Demand is estimated on the basis of MPD-2001 Norm for Year 1991 (225 lpcd Urban, 67.7 rural) and in 1998 (363 lpcd urban, 100 rural) while 2001 & 2005 @363 lpcd and supply data has been provided by Delhi Jal Board. Figures in brackets show units in mgd).*

5.0 Total Water Demand-Supply Scenario

According to the Delhi Jal Board, the current demand for water is 770 mgd as against supply of 600 mgd. By 2005 AD, the projected demand is expected to increase to 1151 mgd. The demand for water far exceeds the installed capacity of Delhi's water works. The water supply resources in Delhi region thus appear to be under continuous pressure. Delhi is almost totally dependent on the neighbouring states for its raw water requirements. According to the records available in the Hand Books (1991, 1992, 1996) of the Directorate of Economics and Statistics, Delhi Administration, the per capita water requirement is 70 gallons/day which is almost double of the per capita water availability (40 gallons/day). The present availability of water fall short of the assessed requirement by about 36%, and this is likely to increase to 48% by 2005 AD.

The status of water supply and its shortage are graphically represented in fig.2.

6.0 Water Resources Data

Delhi is dependent largely on surface water bought from distant sources. A large share of population, almost 50-60% directly or indirectly, is dependent on ground water. In-fact, the shortfall between demand and supply is being met from uncontrolled extraction of ground water. There is no registration of borewells or tubewells in NCT Delhi. Some basic data of Delhi's Water Supply are compiled as follows :

Delhi's Water Supply

Salient Features of Water Utility Data :

The Delhi Jal Board (DJB) is part of the Delhi Municipal Corporation establishment under DMC Act of 1957. It is responsible for production and distribution of potable water and arranging, treatment and disposal of wastewater for the city's estimated population of 12.8 million people.[1] The DJB buys raw water form the Uttar Pradesh irrigation Board and the Bhakra Beas Management Board. It provides water in bulk to the NDMC and the Cantonment Board for distribution in their respective areas. Water for the urban poor is supplied through public standposts, tubewells or deep borehole handpumps or by tankers free.

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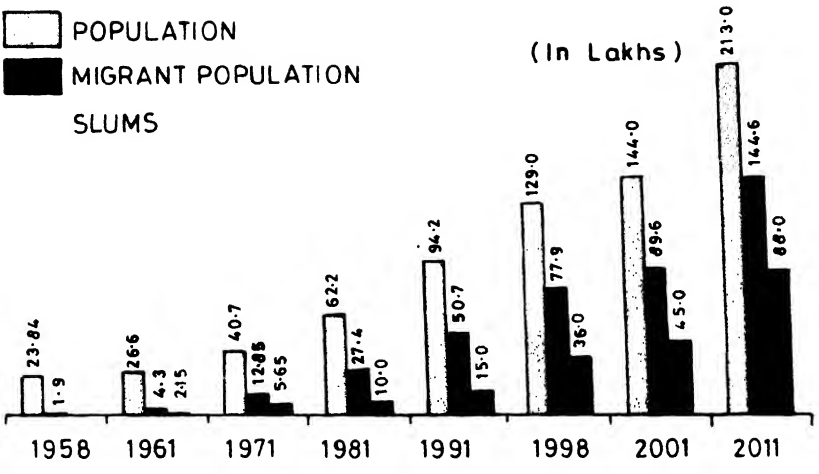


Fig : 1 Growth of Slums in Delhi

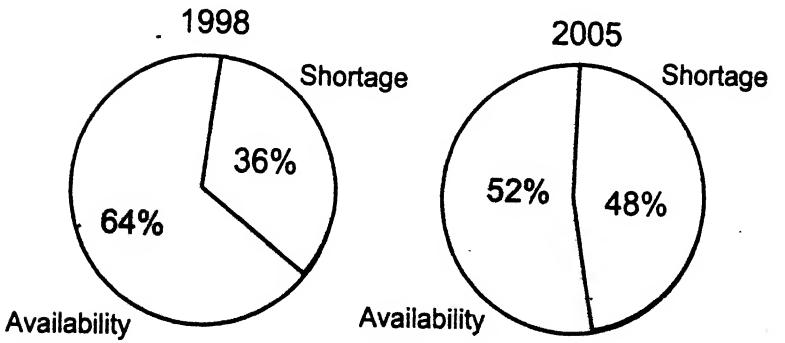
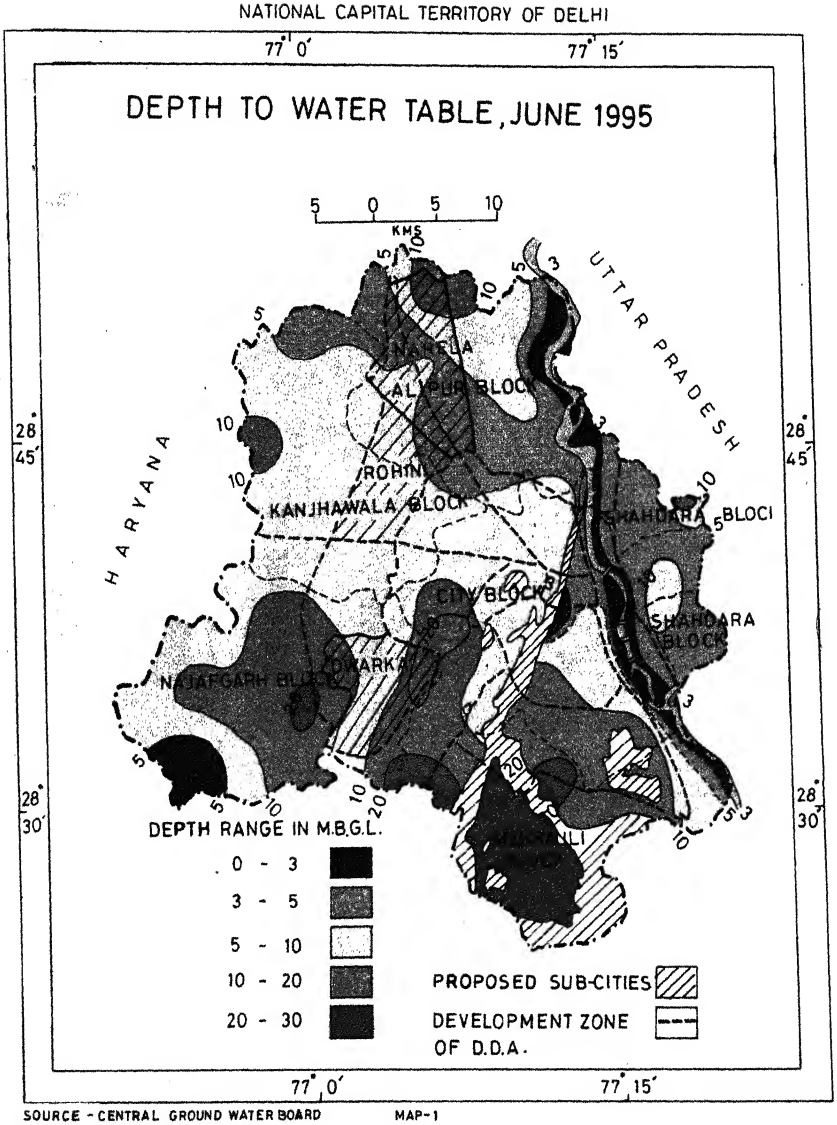
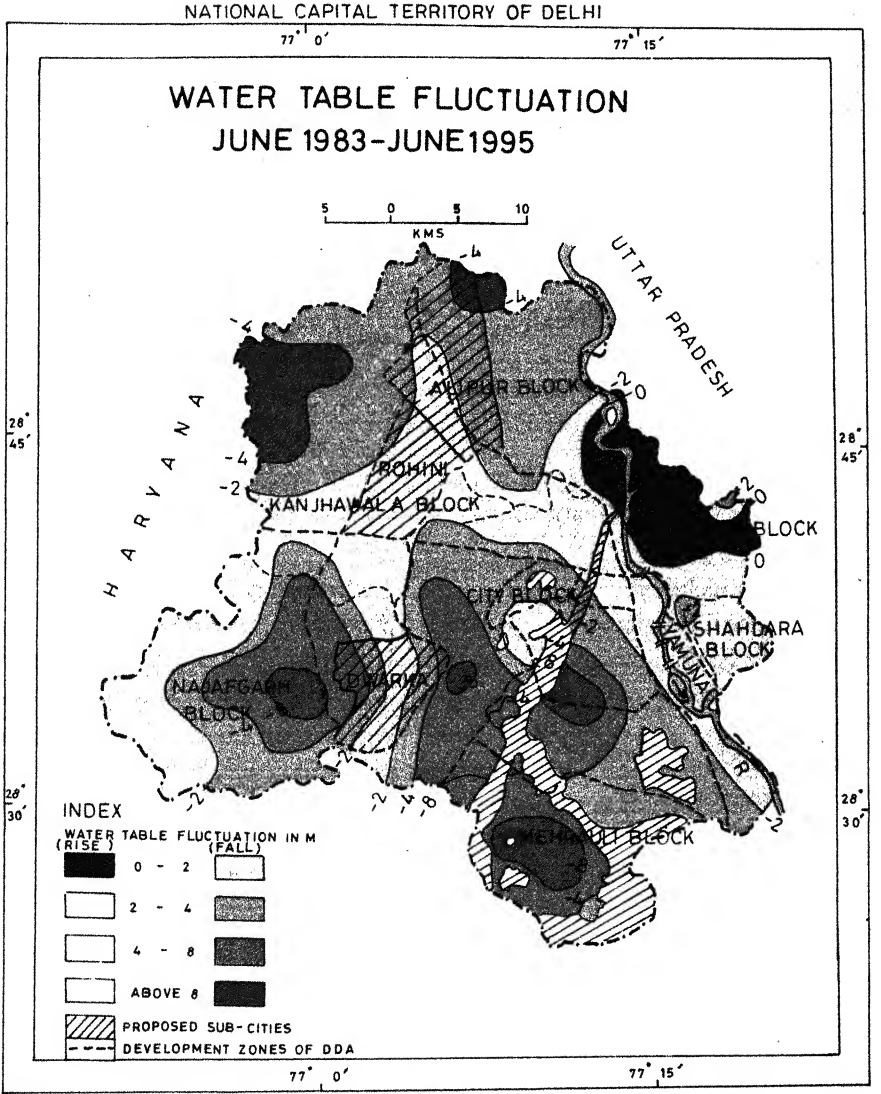


Fig: 2 Status of Water Supply in NCT Delhi



SOURCE - CENTRAL GROUND WATER BOARD NORTH WESTERN REGION MAP-1

Map - 1



SOURCE - CENTRAL GROUND WATER BOARD
NORTH WESTERN REGION

MAP-2

Map - 2

Production/Distribution	
Average Delhi Production	2,610,000 m^3/d
Groundwater	11%
Surface Water	89%
Treatment type	Conventional/Slow Sand Filter
Treatment Capacity	2,590,000 m^3/d
Storage	1,260,000 m^3(48% of total)
Service Area[2]	1,397 sq.km (94% of total)
Service Connections	
House (6.5 persons)	1,096,916
Public Tap (350 persons)[3]	Nil
Industrial	15,000
Commercial Institutional	57,579
Others[3]	Nil
Total	1,169.495
Service Indicators	
Service Coverage[4]	86%
Water Availability[5]	3.5 hours/day
Per Capita Consumption	209 l/c/d
Average Tariff	Rs. 1.43/m^3
Drinking Water[6]	Tap
Efficiency Indicators	
Unaccounted Water[7]	26%
Non-Revenue Water	44%
Unit Production Cost	Rs. 1.55/m^3
Operating Ratio	1.48
Accounts Receivable 4.5 months	
Staff/1,000 Connections	21.4
Annual Water Use (952,650,000 m^3)	
Domestic	60%
Unaccounted for Water	26%
Industrial/Commercial	7%
Others	7%

Contd..

Notes :

1. Includes floating population of about 500,000.
2. Total area of responsibility is 1,483 sq.km.
3. There are about 11,000 public taps that are not metered and not billed and about 7,500 known unauthorised connections.
4. This is for those served by the piped system only. About 11% are served by tubewells and 1% by tankers operated by the utility.
5. Only 30% of consumers get 24-hour water supply. About 15,165 consumers complaints were registered during the year.
6. About 474 water samples out of 48,263 failed the bacteriological tests in 1995-1996
7. In 1995-96, about 3,537 leaks were repaired and 10,100 meters replaced or repaired
8. Other water use and billing represent bulk supply to the New Delhi Municipal Corporation (NDMC) and the Cantonment Board.

(Source : Second Water Utilities Data Book for the Asian and Pacific Region. One US dollar is valued as equivalent to 42 Indian rupee.)

6.1 Sources of Water for Delhi :

The river Yamuna in Delhi is the only major source of surface water (with an annual flow of 10000 cubic metres and usage of 4400 cubic metres). It does not always have enough water to meet the requirements of the capital city and its surrounding areas. Almost the entire flow of the river is diverted by Haryana and Uttar Pradesh into their canals near Tajewala, 225 kms north of Delhi. Irrigation requirements constitute about 96% of the utilisable river water. At Wazirabad the river has a flow of only 48.2 m^3/s. Between Wazirabad and Okhla; 9.28 m^3/s of water is withdrawn and 11.11 m^3/s of waste water is discharged into the river. As soon as Yamuna enters Delhi, it is tapped at the Chandrawal water works for supply to the city. The river leaves Delhi at Okhla where the city's waste water is discharged. The water works at Okhla were shut down because of excessive pollution in the Yamuna. The break-up of the capacity of the existing water works is given as follows :

- Yamuna main stream : 37.5% (546 mld, treated at Wazirabad; 409.5 mld at Chandrawal)
- Western Yamuna Canal : 33.36% (910 mld, treated at Haiderpur)
- Ganga 18.33% (500 mld, treated at Shahdara)
- Ranney wells (huge wells on the river bank) and tubewells 10.81% (295 mld).
- Ground Water (Private tubewells)* - 1230 mld.

* *Field estimates based on estimated number of private tubewells (by INTACH, 1996)*

6.2 Quality of River Yamuna Water in Delhi

The river water is unfit for direct use because the Yamuna river accumulates at least 700 million gallons of waste water every day, three-fourths of which is untreated. The river also carries highly toxic wastes, containing high levels of heavy metals and pesticides indiscriminately discharged by about half-a-million industrial units. According to the Central Pollution Control Board's 1996 Report on Water Quality Monitoring of Yamuna River, the stretch in the vicinity of Delhi is highly degraded and not fit for any drinking use. The available water treatment facilities are not well equipped to remove all types of toxic contaminants.

6.3 Future Raw Water Supply Scenario

Future supply of raw water for Delhi is proposed to be met from reservoirs on the Ganga i.e., Tehri Dam (160 mgd) and Yamuna and its tributaries i.e. Kishau on River Tons (370 mgd), Renuka on River Giri (275 mgd). A total of 805 mgd is expected to be supplied to Delhi through these projects on completion. The present status of these projects is hardly encouraging. The Central Water Commission (CWC), Ministry of Water Resources, Govt. of India, has admitted in recent papers that - "No raw water supplies can be foreseen in the near future from these dams. These projects are capital intensive, financially constrained and environmentally retrograde mega projects which may take another couple of decades to become functional".

Salient features of the reservoirs and stages of execution are given below :

A. Tehri Dam

1. Location	On river Bhagirathi in District Tehri, U.P.
2. Water allocation for Delhi	160 mgd (300 cusecs)
3. Estimated cost of project	Rs.55,830 millions
4. Delhi's share of project cost	Rs.5,000 millions
5. Status	likely to be completed in 2004

B. Renuka Dam

1. Location	Across river Giri in Distt. Sirmour of Himachal Pradesh
2. Water Allocation to Delhi	275 mgd (572 cusec)
3. Cost Estimated	Rs.8050 millions
4. Delhi's share of cost	Rs.8050 millions
5. Status	work not commenced

C. Kishau Dam

1. Location	On river Tons in District Dehradun, U.P. & District Sirmour, Himachal Pradesh, 32 km upstream of Dakpathar
2. Water allocation to Delhi	370 mgd (689 cusecs)
3. Cost allocation to Delhi	Rs. 11100 millions
4. Status	Project report yet to be finalised

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*(**Source** : Central Water Commission, Ministry of Water Resources, Govt. of India)*

6.4 Groundwater Supply Scenario

The rapid urbanisation of Delhi has had an adverse impact on the ground water resources of the state. The water table has declined in most parts by 2m to 8m during the past decade. To meet the water demand-supply gap groundwater withdrawal in the territory is common with individuals and the organised sectors putting in their own structures for getting a dependable and private water supplies. The groundwater development scenario for irrigation, domestic, industrial and other uses has been constantly changing and it is difficult to assess the share of exploitation of each from the common ground water reservoir. While

Groundwater Potential and Exploitation in NCT Delhi

Block	Total replenishable ground water resource (mcm)	Committed net draft Year1991 (mcm)	Present withdrawl for domestic purpose (mcm)	Total ground water withdrawal (mcm)	Balance provision for domestic, industrial & other uses (mcm)
Najafgarh	27.24	32.00	8.19	40.19	Nil
Kanjhawala	44.92	34.00	4.05	38.05	6.87
Alipur	60.70	30.00	6.70	36.70	24.00
Mehrauli	18.75	18.00	10.25	28.25	Nil
Shahdara	17.52	4.00	2.90	6.90	10.62
City	122.50	0.00	110.50	110.50	12.00
Total	291.64	118.00	142.59	260.59	53.49

*(**Source** : Development & Augmentation of Groundwater Resources, CGWB, Report 1996).*

Central Ground Water Board (CGWB) has already sounded an alarm on the unsustainable exploitation of ground water in NCT, Delhi. (refer Map 1 & 2.)

- decrease in discharge
- poor quality
- lowering of water table

The complexities of situation of groundwater occurrence in rock formations, presence of saline groundwater at varying depth and growing urbanisation has influenced the groundwater availability in different parts of Delhi. The irregular and inadequate water supply has resulted in creating self-owned water supply centres based on ground water in both organised and unorganised sectors. This is widespread in areas located at the tail end of the water distribution network due to rapid urbanisation, making the overall ground water scenario grim.

In most parts of Delhi, water levels have declined by 2-8 mts. Maximum fall of over 8 mts. is recorded in Mehrauli block (south), Najafgarh Block (West) and Kanjhawala Block (North) of Delhi. These blocks are on the fringes of urban core and likely to undergo rapid urbanisation by 2005 A.D. (refer map 1 & 2)

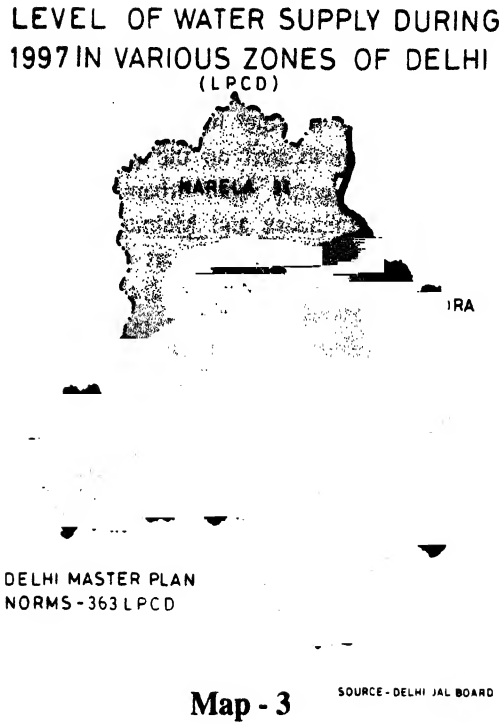
6.5 Quality of Groundwater

In general, the quality of ground water is brackish to saline at shallow depths in the western parts of the state comprising Najafgarh and Kanjhawala block. These are the blocks which are water supply problem areas as they are located on the tailend of the distribution system and are also undergoing rapid urbanisation. In the remaining blocks of Alipur, City, Shahdara and Mehrauli, groundwater is fresh down to considerable depths. A large part of the area to the west of the ridge, covering Alipur Block, Nangloi Block and Najafgarh Block, is severely affected by nitrate and fluoride pollution of groundwater, exceeding the maximum permissible limits (45 mg/l and 1.5 mg/l respectively) in drinking water. The wide range of fluoride (0.1-16.5 ppm) and nitrate (0.01-273.45 ppm) concentrations suggest contamination from both point and non-point sources. Studies conducted by the environmentalists reveal presence of impurities including heavy metals in groundwater. Considerable concentration of nickel, lead, cadmium, chromium in groundwater samples from Motinagar, Kingsway Camp, Meerabagh, Keshavpur and Mukherjee Nagar is reported. Cyanide was also reported from the samples collected at Mall Road and Timarpur area. Once groundwater gets polluted, it is to be treated before use and the removal of heavy metals and other toxic materials like pesticides is very difficult. Further, the recently created landfills are likely to result in biological pollution of ground water.

Despite these problems more than seventy percent of Delhi's population directly or indirectly depend on groundwater for its daily raw water requirements presuming it to be safe and available in plenty. However groundwater is depleting fast and getting severely contaminated with nitrate, fluoride, pesticides and heavy metals from anthropogenic toxic waste sources. This raises more ecological problems. It is almost certain that in case of monsoon failure Delhi cannot be saved from water famine.

6.6 Distribution of Water Supply

While some parts of Delhi get just 30 lpcd, other get as much as 509 lpcd. Map 3 shows the zonewise water distribution. The areas on the tail end of the distribution system are the most water deficit areas.



Map - 3

6.7 Unaccounted Water

The puncturing of the water supply pipelines in slums and resettlement colonies is common. There are several areas where the water pressure is low, the main supply lines have been broken for theft or unauthorised water connections. Distribution losses from the treatment plant to the consumer point is around 30-40%. A considerable amount of drinking water is used for horticulture/watering lawns and for washing a large number of vehicles. The unplanned growth of the city also upsets the hydraulics of the water supply distribution system. However an assessment of such point-source contributed contamination of water resources and distribution losses has not been made rigorously. Almost half of the consumption is not metered. Therefore, most of the time consumption is under-estimated. The unaccounted water is estimated to be as high as 60%.

To meet the demand-supply gap of water, users react by developing strategies. There are about thirty private companies supplying water through tankers (source : groundwater), most of which is unaccounted. Storage tanks and independent borewells are other well known examples of unaccounted waters.

6.8 Under Pricing for Water

Water tariffs are very low for public supply and there is no mechanism of pricing for extraction of groundwater. The level of subsidy is extremely high (79%) for domestic consumption. The majority thinks water is available free. This increases consumption and wasteful utilisation, resulting in low revenue collection. It becomes difficult to cover the cost of production and hinders investment.

Thus, the issue of water resources data is multidimensional and related to the assessment of available water, its existing depletion, degradation, pollution, scope for augmentation, reuse/recycling of water, water pricing and distribution of water. However, like surface water resource management, not many concerted efforts have been made to manage underground water due to the complexities of the aquifer system.

Water Production/Consumption and Percentage of Losses in Delhi

Water Production/Consumption	1993-94	1992-93
Consumption build per day (MLD)	1286	1274
-Production per day (MLD)	2270	2143
%Water Billed	57	59
%Unaccounted water	43	41
%Cost recovery	75.6	72
-Consumption paid	973	917
%of consumption paid	43	43
%of water production actually not paid	57	57

*(**Source** : Data from Delhi Jal Board, 1995)*

7.0 The Actual Scenario

No lessons have, apparently, been learnt by water supply Engineers/ Managers or by the Town Planners. In fact water supply has gone from bad to worse with colony after colony being built without providing sufficient water to their inhabitants. The basis of this endemic problem is extensive urbanisation and continuous overexploitation of groundwater with little chance of augmenting raw water from surface reservoirs in the near future. A comprehensive analysis of Master Plan for Delhi -2001 reveals that standards, norms and development code dominate which do not have appreciation of the ground situation and the mismatch between the urban planning and development vis-a-vis emerging water supply scenario in NCT Delhi.

Comparison of Water Charges Billed for Different Cities in India with Different Levels of Consumption

	20 KL (in Rs.)	40 KL (in Rs.)	60 KL (in Rs.)
Delhi (1)	9.1	27.3	37.1
Chandigarh (2)	14	49	79
Jaipur (3)	21	45	69
Bangalore (2)	8	21.5	49
Ahmedabad (2)	30	60	90
Hyderabad (2)	19	57	65
Baroda (2)	18	36	54

(***Sources:*** *1. Data from Delhi Jal Board.*

2. Data from A.S. Dhami: "Water Management of mega cities charges for water through metering of flat rate system" in Indian Water Works Association, 26th Annual Convention, 1994.

3. Data from PHED, Rajasthan, Jaipur)

8.0 Critical Aspects of Environmental Concern in the Water Resources Sector

8.1 *Contractor's Approach to Augment Raw Water*

The main measure taken by the Delhi Jal Board is construction of more treatment plants and optimising production of water at the existing plants without ensured raw water availability. For the planned projected availability of water authorities are banking on long term measures (refer table).

However, these capital intensive, financially constrained and environmentally retrograde projects (dams) may take 15-20 years for completion. Some of these may not see light of the day.

8.2 Uncontrolled Urbanisation and Landfilling

Landfilling is still the most common way of disposing municipal and industrial waste. Whether it is an urban or rural area no clear guideline exists for such disposal activities. During the monsoon the surface run-off water has a general tendency to collect in these garbage dumps. Subsequent leaching of toxic contaminants through

Status of Proposed Water Treatment Plants

S. No.	Plants	Status	Capacity	Source
i	North Shahdara	Not finalised	100	Proposed dams at Tehri/Renuka/Kishau
ii.	South Shahdara	Not finalised	40	Proposed dams at Tehri/Renuka/Kishau
iii.	Nangloi	completed (Raw water not available)	40	Delhi Tail Distributary/ WJC
iv.	Bawana	Not finalised	20	Delhi Tail Distributary/ WJC
V	Dwarka (Bakarwal Village)	Not finalised	100	
Total			**300 mgd**	

*(**Source**: Delhi Jal Board, GNCTD)*

these landfills also leads to extensive contamination of groundwater at many places. Such landfills are increasing in number almost in every part of the city due to indiscriminate urbanisation.

8.3 Indiscriminate Groundwater Utilisation

Groundwater is utilised in Delhi for agricultural, domestic and industrial purposes. Because of the inadequate water supply people overuse groundwater in both organised and unorganised sectors. But the impediment to augmenting water supply is widespread decline in the groundwater table in different parts of the region. Unplanned development of groundwater may further disturb the hydrological balance-leading to decline in productivity of wells, increasing pumping cost, more energy requirement, more seepage losses from canals etc. Another hurdle in further development of groundwater is the fact that more than sixty percent of underground water in the region is brackish. Hence over-exploitation of water resources must be checked and emphasis should be laid on the overall understanding of the hydrological system.

8.4 Groundwater Availability

The availability of this important natural resource has been taken for granted. Increasing groundwater use and pollution have crossed the sustainable limits in many areas due to the fast changing landuse pattern.

In Delhi region, the shallow aquifers groundwater is presumed to be mainly recharged from infiltration of rainfall. But, the available exposed land surface for direct infiltration of rainfall, has declined significantly due to urbanisation. The recharge of deeper aquifers is presumed to be mostly taking place through leakage from the upper unconfined aquifer and partly from lateral groundwater flow from the north and south-west areas. However, reliable quantitative estimates of annual groundwater recharge are not available. Further the spatial and temporal variation of recharge, with highly erratic intensity and distribution of rainfall, has not at all been studied in this region. The classical hydrological studies based on measurements of water table fluctuations and pumping tests do not provide all the necessary information needed for finding a solution to the problems outlined above.

8.5 Groundwater Degradation Problems

Lateral flows from the western parts in NCT contribute 20-70% recharge to the groundwater system. Such contributions have little practical relevance because the lateral flow water carries various types of contaminants through specific flow-pathways. Moreover, indiscriminate pumping of groundwater results in mixing of contaminated/saline water with fresh water bodies through these flow-paths, within a block and between to adjacent blocks. This leads to spreading of contamination/salinisation and depletion of available fresh water potential. The area with contaminated groundwater increases annually by 1-10%. This means an annual extension of 14-148 sq.km of the area of polluted groundwater.

Several studies undertaken by the Indian Agricultural Research Institute (IARI) clearly indicate that infiltration of irrigation water/ surface runoff water from the surrounding farm lands, alongwith fertilizer nitrate and chemicals containing fluoride salts in soil, spoils groundwater quality. Irrigation with such water, together with man-made land disposal for wastes, is likely to exceed the sink capacity of the watershed soils over a period of time. This means increasing the return flow of high fluoride and high nitrate irrigation water to groundwater. The characterisation of such contamination processes is of paramount importance from the point of input resource management.

The Delhi area is notorious for stagnation of surface run-off water, particularly during the monsoon period. The stormwater drains in the city are also faulty and clogged at many places. There are innumerable open wells and uncovered water tanks. The stagnation of stormwater facilitates the breeding of mosquitoes and spread of malaria. Studies indicate that the slow process of infiltration of water form such stagnated water pools and puddles also results in a considerable pollution and salinisation of groundwater. Most of these waterlogged areas produce vector-borne diseases.

Besides this, there are several areas where groundwater is severely contaminated with hazardous micro-organisms and heavy metals such as chromium, nickel and pesticides. During 1955-56 a world record was created when an estimated 29,000 persons developed jaundice following the contamination of drinking water by toxic

contents of a sewer drain from Najafgarh in West Delhi. The mixing of sewage and drinking water apart, another cause of diseases is the drawing of water from pit taps. Epidemiological studies show that even now the areas with contaminated water report a significant number of epidemic cases of water borne diseases like jaundice, cholera, gastroenteritis and typhoid, mostly in urban and semi-urabn areas.

8.6 Groundwater Occurrence and Recharge - Availability Problems :

The groundwater in the wells are mixtures of varying proportions of different sources and the aquifer in the area does not constitute a homogenous system in its lateral extent. Natural mixing in the aquifer proper is a slow process. Occurrence of moderately to highly saline groundwater in more than sixty percent of the area suggests that the groundwater flushing is incomplete and that the amount of contemporary recharge is very limited or even absent at many places. In comparison with direct recharge from rainfall, localised and indirect recharge are often the most significant sources of natural recharge.

High intensity rainfall and lateral flow from surrounding areas in the west are the main contributors to the groundwater recharge. Recharge from high intensity rainfall contributed flood is not a rapid process, but occurs through stagnant water pools which surround areas and farm lands and constitute an identifiable water type distinct from rainfall water. Thus, rainfall recharge being depression focussed, certain parts of groundwater recharge zones may never receive direct infiltration to the water table. A rough estimate suggests that out of the average annual rainfall about 70% drains off as surface run-off. There is a need to conserve this large amount of water, which can be used for water supply after appropriate treatment. Hard urban surfaces and increasingly urbanisation of watersheds has led to loss of this rainwater through rapid and increased run-off.

8.7 Reuse and Recycling of Waste Water

It is estimated that almost 40% of the 1700 mld of total sewage generated in Delhi is discharged into the Yamuna river without any treatment. Even 994 mld treated effluent does not receive full secondary treatment, and therefore, partially treated sewage further

adds to the pollution of the river. As noted in the Indo-Dutch Project (January, 1996) "Risk Assessment of the Yamuna River, the water treatment plants remain shut down many times in a year due to high level of pollution loads. A high-powered committee, appointed by the Lt., Governor in 1984, felt that one of the major reasons for the pollution of the river was the sharp rise in urban population and the correspoinding increase in the number of sub-standard unauthorised residential colonies, slums etc., where more than 30% of the capital's population resides.

9.0 Concluding Remarks

Experts are beginning to focus on reducing transmission losses, increase in pricing, demand management, conservation and recycling of water and are banking upon long term measures and distant sources for additional raw water augumentation. The concepts of groundwater management and in situ water augumentation are being promoted by environment conscious NGO's, groups and other environmentalists etc. It is increasingly felt in all circles that groundwater management would substantially improve the water regime in Delhi at comparatively lower costs in a eco-friendly manner in time.

Some of the important questions which the planners and decision makers confront are :

- what is the origin and rechargeability of groundwater?
- is the water of usable quality?
- is the water available in adequate quality?
- where is the location of recharge intake areas, what is the temporal and spatial variability of recharges; how frequently the recharge takes place; is there any interlinkage between groundwater and surface water; if so what is the extent of such interaction?

Planning for the development of groundwater resources, in general, may require only descriptive interpretation of existing and readily obtainable hydrological and geological information. But in addition to the existing above groundwater management in urban areas,

we would require to understand water and the city vis-a-vis existing Urban & Regional Planning as well as future growth. The present urban planning norms and standards do not appreciate the need to augment the urban water regime. However, the choices based on the best obtainable detailed scientific information, of all hydrologic aspects offer a hope of sustainable development of water supply in the NCT-Delhi area. In this context alternative solutions have to be considered. Perhaps the dependence on controversial dams and canals can be reconsidered. Keeping this in mind the suggested alternative strategies are mentioned below.

a) Groundwater Protection Strategies

Recharge - Withdrawal Balance : To protect the groundwater quality and to prevent its further depletion, water extraction must be balanced by (what is estimated to be) the recharge calculated not only on the basis of the intensity and distribution of modern seasonal rainfall but also by improved direct observational methods. All such estimates should be revised, at regular intervals, on the basis of data for reconsideration because the non saline/non-contaminated water reserves may not be actually related to the present day recharge regime. Wherever feasible new approaches should be adopted to enhance recharge through low lying areas where surface run-off gets collected during high intensity rainfall, instead of allowing the water to stagnate. Legislation needs to be introduced and enforced to restrict indiscriminate installation of tubewells and withdrawal of groundwater.

Protection of Recharge Zones : For developing aquifer protection strategies it is desirable to define the hydrogeological and geochemical properties of the groundwater system. Futhermore, the zones of groundwater recharge need to be clearly identified and revised in relation to landuse changes in order to restrict or eliminate waste disposal activities in these areas. The risk assessment of contamination must consider not only the nature of the contaminants but also the pathways between contaminant source and the water-supply well, the velocity of groundwater along the pathways and the attenuation capacity for the contaminants in the aquifer.

b) Rainwater Harvesting and Conservation of Surface Run-off

Quite a significant amount of total annual rainfall (2,02,000 million gallons or 553 MGD) drains off as surface runoff. Such waters should be artificially stored in underground reservoirs, natural drainage channels, abandoned quarries, historical water tanks, check dams, natural depressions, ponds, Yamuna flood plain, reservoirs and by rooftop harvesting. Such stored water can be used after treatment. However, in Delhi the storage of large quantities of water is not possible everywhere. Therefore, we must depend on people's capacity to store water, taking benefit of the building by-laws, in underground tanks for non drinking usage.

The alternative approaches appear feasible in principle and require speedy implementation, through effective popular involvement and close coordination of various Government agencies. However, the implementation of such proposals will face several financial, technical and legal difficulties with respect to the jurisdiction of different agencies. The benefits of the suggested approaches can be assessed only after the system has worked efficiently for a few years. By the time these proposals are put into operation, the pressure on groundwater is bound to increase further.

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References

1. Anonymous, 1991, 1992, 1996. Directorate of Economics and Statistics Hand Book, Delhi Administration.
2. Banerji Rajat and Max Martin, 1997. Poison River. Down to Earth, February 28: 28-38.
3. Bureau of Economics and Statistics Hand Book, 1991, 1992, 1996, Delhi Administration.
4. CBPCWP, 1979, Central Urban Population series CUPS/1/1978-79, Central Board for Prevention and Control of Water Pollution, New Delhi, Govt. of India, 1-13 (abridged).
5. Civic Guide (1996). Municipal Corporation of Delhi, New Delhi. Datta, P.S., 1997. Stable isotopic investigations for groundwater management and sustainable environment. Nuclear Research Laboratory, IARI Report.
6. Datta, P.S., 1990. Deuterium and oxygen-18 studies in groundwater of Delhi area, India-comment. J. Hydrol., 113: 385-389.
7. Datta, P.S., Bhattacharya, S. K. and Tyagi, S.K., 1994. Assessment of groundwater flow conditions and hydrodynamic zones in phreatic aquifer of Delhi area using oxygen O^{18}. Proc. Intn Workshop on "Groundwater Monitoring and Recharge in Semi-Arid Areas", Hyderabad, IAH/UNESCO Publication, S IV : 12-24.
8. Datta, P.S., Bhattacharya, S. K. and Tyagi, S.K., 1996. ^{18}O studies on recharge of phreatic aquifers and groundwater flow-paths of mixing in Delhi area. J. Hydrol., 176: 25-36.
9. Datta, P.S., Deb, D.L. and Tyagi, S.K., 1996. Stable isotope (^{18}O) investigations on the processes controlling fluoride contamination of groundwater. J. Contam. Hydrol. 24(1):85-96.
10. Datta, P.S., Den, D.L. and Tyagi, S.K., 1997. Assessment of groundwater contamination from fertilizers in Delhi area based on ^{18}O, NO_3^- and K^+ composition. J. Contam. Hydrol. 27(3-4) : 249-262.
11. Datta, P. S., Tyagi, S. K. and Chandrasekharan, H., 1991. Factors controlling stable isotopic composition of rainfall in New Delhi, India. J. Hydrology, 128 : 223-236.
12. Datta, P.S. and Tyagi, S.K., 1995. Isotopic investigations on groundwater recharge conditions and flow regime in Delhi region- A review. Proc. International Conf. Water & Energy 2001, Oxford and IBH Publn. Vol. II : 629-642.

13. Datta, P.S. and Tyagi, S.K., 1996. Major ion chemistry of groundwater in Delhi area : chemical weathering processes and groundwater flow regime, J. Geol Soc. Ind. 47 : 179-188.

14. Datta, P.S. and Tyagi, S.K., 1996a. Groundwater surface water intermixing model and recharge conditions in Delhi area as derived from ^{18}O and D. Proc. Intn. Conf. on Hydrology and Water Resources, New Delhi, 1993. (Eds: Vijay P. Singh and Bhism Kumar) Kluwer Acad. Pib., Netherlands, Vol. II : 103-119.

15. Delhi Vision-2001 : Civic Infrastructure and Environment (1996). Proceeding of Seminar organised by PHD Chamber of Commerce and Industry and Govt. of NCT of Delhi.

16. Development and Augmentation of Groundwater Resources of NCT Delhi (Unpublished Report 1996). Central groundwater board, Ministry of Water Resources, Govt. of India.

17. Diwakar Ashok, 1993. Facing Water famine, The Hindustan Times, New Delhi, July 2; p.11. Down to Earth, 1993. Seeking ways to quench Delhi's growing thirst, March 15 issue : p.14.

18. Eriksson E., 1976. The distribution of salinity in groundwater of the Delhi region and recharge rates of groundwater. In : Inter- pretation of invironmental isotope and Hydrochemical Data in Groundwater Hydrology, International Atomic Energy Agency, Vienna, 171-177.

19. Indo-Dutch Government Project Report, January 1996. Risk Assessment of the Yamuna River.

20. Jain Sandhya, 1987. Industrial effluents poison Yamuna, The Hindustan Times weekly, New Delhi, January 25: p.13.

21. Manual of Water Supply and Treatment (Third Edition) Prepared by Expert committee, constitutioin by Govt. of India (1991). Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development, New Delhi.

22. Rana K.S., S.C. Sud and A.K. Mohinta (1997). Overview of reservoirs upstream of the National Capital Region Central Water Commission, Ministry of Water Resources (Govt. of India) (unpublished). (A paper presented at a seminar organised by INTACH "Water Resources of NCR" held on November, 1997).

23. Seth, N.N. and Khanna, S.P., 1969. A note on groundwater condition in Delhi area. Geological Survey of India. Misc. Publn., 14 (Part-III) : 101-110.

24. Sett, D.N., 1964. Groundwater geology of the Delhi region. Bull. Geol. Survey. India, Series-B. 16: 1-35.

25. Spatio-Economic Development Record, Vol.2 ,No.6, Nov-Dec (1995), (Spl. Issue of INTACH initiated on Harvesting water).

26. The Hindustan Times, June 1, 1987. Pollution threats by small units.

27. The Hindustan Times, May 28, 1994. Yamuna Water : Haryana yet to release due share.

28. ZERAH, Marie Helene (1995). "Towards a more efficient management of water supply in Delhi" Issues of Water pricing and cost-benefit analysis Institute of urbanism, Paris, France. (A Paper presented at a seminar organised by INTACH : Delhi's water : problems of Alternatives "held on 8th July, 1995).

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Memorandum of Understanding Between Uttar Pradesh, Haryana, Rajasthan, Himachal Pradesh and National Capital Territory of Delhi Regarding Allocation of Surface Flow of Yamuna.

1. WHEREAS the 75% dependable notional virgin flow in the Yamuna river upto Okhla has been assessed as 11.70 Billion Cubic Metres (BCM) and the mean year availability has been assessed as 13.00 BCM.

2. AND WHEREAS the water was being utilised by the Basin States ex-Tajewala and ex-Okhla for meeting the irrigation and drinking water needs without any specific allocation.

3. AND WHEREAS a demand has been made by some Basin States on this account and the need for a specified allocation of the utilisable water resources of river Yamuna has felt for a long time.

4. AND WHEREAS to maximise the utilisation of the surface flow of river a Yamuna a number of storage projects have been identified.

5. AND WHEREAS the States have agreed that a minimum flow in proportion of completion of upstream storage going upto 10 cusec shall be maintained downstream of Tajewala and downstream of Okhla Headworks throughout the year from ecological consid erations, as upstream storage are built up progressively in a phased manner.

6. AND WHEREAS it has been assessed that a quantum of 0.68 BCM may not be utilisable due to flood spills.

7. NOW THEREFORE, considering their irrigation and consumptive drinking water requirements, the Basin States agree on the following allocation of the utilisable water resources of river Yamuna assessed on mean year availability.

a.	Haryana	5.730 BCM
b.	Uttar Pradesh	4.032 BCM
c.	Rajasthan	1.119 BCM
d.	Himachal Pradesh	0.378 BCM
e.	Delhi	0.724 BCM

Subject to the following :

i) Pending construction of the storage in the upper reaches of the river, there shall be an interim seasonal allocation of the annual utilisation flow of river Yamuna as follows :

States	Seasonal Allocation of Yamuna Waters (BCM)			
	July-Oct	Nov.-Feb.	March-June	Annual
Haryana	4.107	0.686	0.937	5.73
Uttar Pradesh	3.216	0.343	0.473	4.032
Rajasthan	0.963	0.07	0.086	1.119
Himachal Pradesh	0.19	0.108	0.08	0.378
Delhi	0.58	0.068	0.076	0.724
Total	9.056	1.275	1.652	11.983

Provided that the interim seasonal allocations will be distributed on ten daily basis.

Provided further that the said interim seasonal allocations shall get progressively modified, as storage are constructed, to the final annual allocations as indicated in para 7 above.

ii) Separate agreement will be executed in respect of each identified storage within the framework of overall allocation made under this agreement.

iii) The allocation of available flows amongst the beneficiary States will be regulated by the Upper Yamuna River Board within the overall framework of this agreement.

Provided that in a year when the availability is more than the assessed quantity, the surplus availability will be distributed amongst the States in proportion to their allocations.

Provided also that in a year when the availability is less than the assessed quantity, first the drinking water allocation of Delhi will be met and the balance will be distributed amongst Haryana, U.P., Rajasthan and H.P. in proportion to their allocations.

8. This agreement may be reviewed after the year 2025, if any of the basin States so demand.

9. We place on record and gratefully acknowledge assistance and advice given by the Union Minister of Water Resources in arriving at this expenditious and amicable settlement.

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Part - II
Delhi's Solid Waste Disposal and Management

S. K. Rohilla & S.P. Bansal

Views expressed are that of the authors and not of the organisations they represent.

Summary

National Capital Territory (NCT) of Delhi, with its relatively high percentage of open spaces and ground character, is categorised as one of the most polluted metropolitan cities in the world. Of more than 8000 tonnes of waste generated in the city per day, on an average, roughly 25-35% remains uncollected causing environmental degradation. With the present rate of growth of population and change in life styles the quantity of waste generation is likely to be 10,000 tonnes per day by the end of the year 2001.

The Municipal Corporation of Delhi (MCD) is the single largest body that looks after the majority of solid waste collection and disposal in Delhi. The other local bodies i.e. NDMC and Delhi Cantonment Board collect and manage the waste in the areas under their jurisdiction. In the absence of direct house-to-house collection of waste, the community bin system is mostly in practice. Waste produced in unauthorised colonies and marginal areas, market, hospital and industries create a significant problem of collection, transportation and safe disposal.

There are weaknesses in the existing practices of processing and disposal of wastes followed by local bodies. The reports of National Environmental Engineering Research Institute (NEERI) reveal serious environmental concern in respect of ground water, land and air pollution caused by solid waste land fill sites used in different parts of the city.

An analysis of solid waste management in NCT Delhi reveals the following specific areas of improvement :

i. Working out specific programmes for involvement of private sector, cooperatives and NGOs in better waste management.
ii. Inter agency coordination and advance planning.
iii. Separate arrangements for handling of specialised wastes.
iv. Improvements in the existing system of land fills.
v. Modifications in the laws dealing with solid waste management.

Introduction

Solid Waste is strewn all over Delhi. (Source - Public Interest Litigation w.p. no. 286, 1994 Dr. Wadehra vs. Union of India). During 1996, the estimated quantity of waste generated was around 7880 tonnes per day. However, waste collection is inadequate and on an average, roughly 25-35 percent of total waste generated remains uncollected. This is one of the biggest sources of environmental degradation in the capital city. It contributes to the pollution of air, water and soil. The civic agencies like Municipal Corporation Delhi /New Delhi Municipal Corporation and Delhi Cantonment Board which are responsible for collection, disposal and treatment of solid waste have failed to provide a clean and healthy environment to the residents of Delhi.

In most localities the designated garbage dumps are over flowing and the number of open garbage dumps in the by lanes, parks and road side are increasing. Besides being unaesthetic, these garbage dumps are health and environment hazards for the ten million people who live in Delhi. Ragpickers, pigs, cows, dogs, cats and monkeys are seen wallowing in this garbage. This rotting biodegradable matter is a breeding ground for flies and mosquitoes. Germs causing plague, tuberculosis, cholera, dysentery, diarrhea, leprosy, eye infections, skin allergies and breathing problems multiply here.

At present there are 5000 garbage dumps in Delhi. 5 percent of Delhi's land mass is being choked by the garbage. This 5 percent has become a wasteland, its utility is steadily declining and soil quality is deteriorating. The environment of the capital city is under constant threat. The solid waste collection, transfer, treatment, safe disposal and its management with growing population and fast pace of city development, is becoming more and more complex.

By Dr.(Ms.) Iqbal Malik - A "Vatavaran Report, 1996"

2.0 Study Area Profile

National Capital Territory (NCT) Delhi situated on the banks of the river Yamuna is flanked by Uttar Pradesh in East and Haryana to the North, South and West. The Delhi region is a part of the Indo-gangetic alluvial plains, at an elevation ranging from 198 to 220m above msl, with an area of 1483 sq.km. The area lies between 28024'17"N-28053'00" N and 76050'24"E-77020'37" E.

2.1 Climate and Physiography

The Climate of the region is semi-arid. The mean minimum and maximum temperatures are 18.70 C and 30.50C respectively. During the hottest months of May and June, temperature commonly exceeds 40^0 C.

Almost flat plains exist extensively throughout the region, transacted by a rocky ridge in the south-eastern part. The ridge has a maximum elevation of 306.63 m above msl in the south-eastern part of the area and rises about 15 to 91 m above the surrounding plains. Under the Supreme Court order mining and quarrying of stone/gravel has been banned in Delhi and huge voids have resulted due to mining and quarrying in South Delhi at Okhla, Badarpur, Bhatti, Jaunapur and Mehrauli. Some of these abandoned quarry pits have been identified as potential land fill sites.

2.2 Settlement Pattern, Population and Slums : Growth and Projections

Of the total area of 1483 sq.km., 685 sq.km. (46%) is urban and 798 sq.km., (54%) is rural and on the basis of projected urbanisation the position by the year 2001 will change to about 57% urban and 43% rural area. Area adjacent to the river Yamuna on the both sides is highly urbanised and forms the urban core, which includes 130 urban villages. The outlying areas consist of 239 villages some of which are large enough to be classified as census towns. There is a proposal for developing 16 Growth Centres and 33 Growth Points for rural areas. Each village earmarked as Growth Centre shall serve as a mini town. Delhi Development Authority (DDA) also plans to develop three sub-cities namely Dwarka (to accommodate 12 lakh), Narela (14 lakh), Rohini Extension (8.0

lakh) - almost 34 to 35 lakh population to be accommodated by 2005 AD in NCT Delhi.

The city continues its expansion - vertical and horizontal. A continuing series of small townships with their own characteristics, commercial and industrial areas, satellite townships - these characterise today's Delhi.

The city's environment appears to have degraded, primarily because of fast rising population, expanding industrialisation, indiscriminate use of land, inadequate civic facilities and poor public response to the needs of environmental protection. In 1947, with partition, Delhi saw a large influx of refugee population and the city grew in all directions. This started a new chapter in the growth of Delhi. After the formation of Delhi Development Authority (DDA) in 1957, a 20 year masterplan was approved in year 1962. From the urbanised area of 18000 ha., it was proposed to enlarge the urban area to 44,736 ha. The development of Delhi on massive scale and centralisation of the resources, induced the development of towns on the periphery of Delhi border, viz., Ghaziabad, NOIDA, Gurgaon, Sonepat etc. Their development rather than relieving or deflecting population from Delhi, created more pressures on basic services like solid waste - collection, disposal and management.

From a population of barely 4 lac in 1901, it increased to 17.44 lac in 1951; 62.20 lac in 1981; 94.20 lac in 1991 and 108.4 lac in 1996. It is estimated that by the turn of the century the population would grow to over 130 lac. The decadal growth rate of Delhi for past few decades has been in the order 50-60% as evident from the graph. (Refer figure 1)

Immigration is a major cause of Delhi's rapid growth. The neighbouring states of Uttar Pradesh, Haryana and Rajasthan account for over 70% of the migration. There are 1071 unauthorised /non-regularised colonies and about 1400 jhuggi clusters. The number of squatters to Delhi have increased five fold since 1961. At present, Delhi's 35% of the total population is said to be in squatter/slums, unauthorised colonies. It is estimated that by 2011 the number of people living in such areas would be equal to Delhi's

present population. The civic authorities are called upon to provide services in these settlements without any return of revenue from them.

3.0 Planning Provisions for Waste Disposal

3.1 Master Plan 1962 : *Master Plan for Delhi* - 1962 (MPD-62) was the first attempt at comprehensive urban planning in the National Capital Territory (NCT) of Delhi. Keeping in view the needs of the growing city, the plan made specific recommendations for refuse disposal. It was suggested that cut-up and low-lying lands be reclaimed by sanitary landfilling. The sites selected were expected to reduce transport distance and help reclaim such lands for use as city greens. A system of community bins for the collection of refuse was proposed. In case of multi-storeyed buildings the use of refuse-chutes was recommended. Ten disposal sites were identified in the plan.

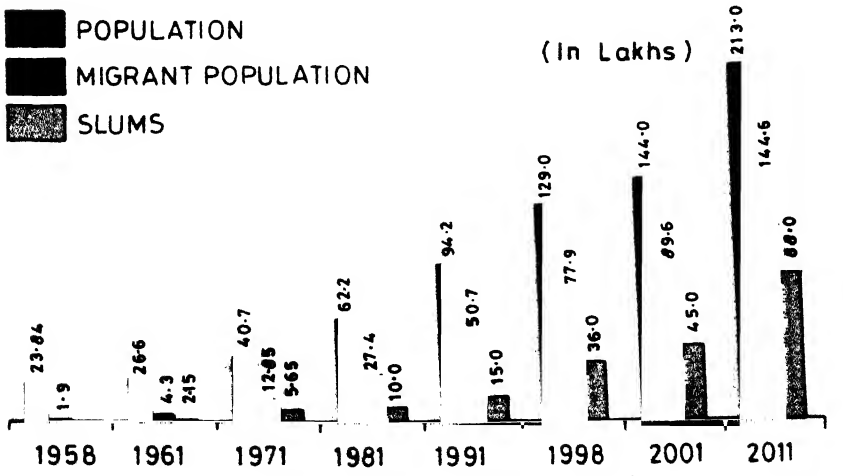


Fig : 1.Growth of Slums in Delhi

3.2 Master Plan for Delhi 2001 : It is an extensive modification of MPD-62. The Delhi Development Authority, based on fresh planning studies and experiences of plan implementation, prepared a modified document entitled Master Plan for Delhi Perspective 2001 (MPD-2001). The plan, with its thrust to improve the quality of life in the city, made specific recommendations for improved availability/accessibility of essential infrastructure. The provisions regarding solid waste management were made based on detailed studies conducted by National Environmental Engineering Research Institute (NEERI). NEERI, with the help of all the local bodies i.e. Municipal Corporation of Delhi (MCD), New Delhi Municipal Corporation (NDMC), Cantonment Board and DDA, critically analysed the existing systems of waste collection, transportation and disposal.

Considering the nature of solid waste and the economic aspects of its disposal, a major part of solid waste in the city was proposed to be disposed of in sanitary land-fills. Accordingly, following seven sites as shown in the map no. for sanitary land-fills have been proposed in the plan :

Site Description	**Area in ha.**
1. Near Hasthal village in west Delhi	26.0
2. On Ring Road near village Sarai Kale Khan	20.0
3. In the north west	58.5
4. Near Gazipur dairy far, Trans-Yamuna Area	52.0
5. Near Timarpur existing landfill	40.0
6. Near Gopalpur village in north Delhi	20.0
7. Near Jahangirpuri	12.0

*(**Source** : Master Plan for Delhi - 2001)*

In addition to above sites, and with a view to avoid ground water contamination, the plan recommended further improvement of sanitary land-fill on the Ring Road near Nizamuddin Station by providing a water prevention layer at the bottom. Waste produced from vegetable and fruits markets having high organic contents is

proposed for treatment in the compost plants-one each, run by MCD and the NDMC (located near Okhla Sewerage Treatment Plant). Hospital waste, containing harmful micro-organisms, would be burnt separately in the incinerators. To avoid bird menace special care in the form of covered dustbins and quick removal of waste is proposed in areas within 10 km from the airport. The requirement of dustbins and dhallaos have been worked out on the basis of following norms of solid waste generation :

- NDMC area : 0.67 kg/capita/day
- MCD area : 0.60 kg/capita/day

Adequate precautions for dumping of about 4,000 tonnes of fly-ash produced from thermal power-stations is proposed to avoid pollution of river Yamuna.

4.0 Vital Statistics About Delhi's Solid Waste/ Garbage

a. Garbage Generation–Existing and Projected

Year	Population (lakhs)	Garbage Generated (MCD, NDMC & Cantt. Board) Per day (Metric tonnes)
1981	62.20	4500
1991	94.20	6500
1996	108.40	7880
2001	128	10000

(Source: MCD, NDMC & Delhi Cantt. Board, 1996)

b. Waste Generation Characteristics at Global Level

Country	Refuse Generation Rates (kg/capita/day)
U.S.A.	2.40
U.K. (Great Britain)	0.74
Singapore	0.87
Egypt	0.50
Pakistan	0.60
India	0.50

(Source : UNEP/WORLD RESOURCE INSTITUTE, 1988)

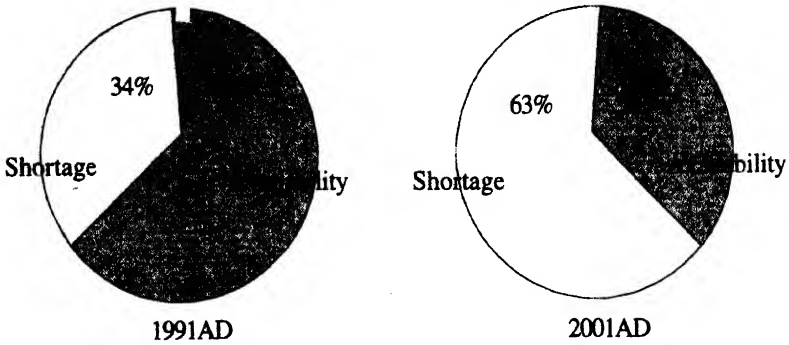


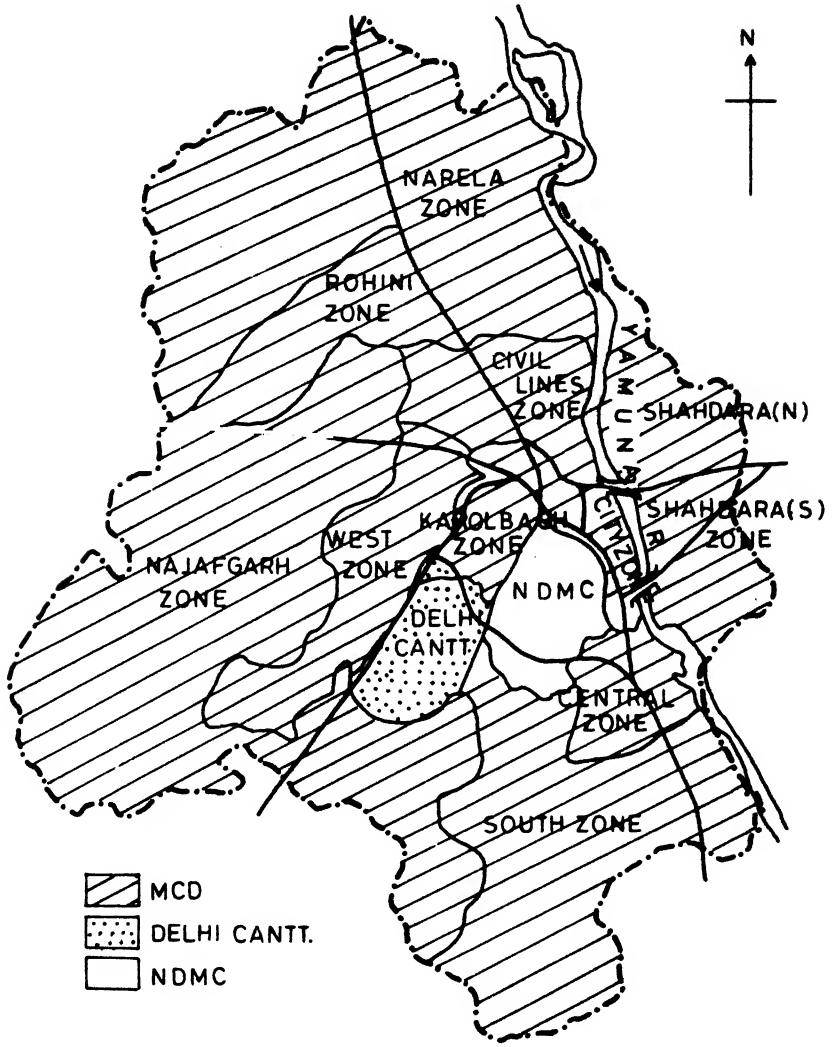
Fig 2: Excessive Pressure on Services Solid Waste Management

c. Quantity of Garbage Generated and Garbage Cleared in Major Cities of India

City	Garbage Generated in Tonnes/Day	Garbage Cleared in Tonnes/Day	Percentage of Garbage cleared	Annual Municipal Budget in Crs. of Rs.
I. India				
1. Delhi	7880*	4850	61.5	1,016.38
2. Calcutta	3500	3150	90.0	250
3. Bombay	5800	5000	86.2	2,436
4. Madras	2675	214	80.0	145
5. Bangalore	2130	1800	84.5	237
II South & S.E. Asia				
Karachi	4500	1500	33%	-
Dhaka	3000	1500	50%	-
Jakarta	6741	4719	70%	-
Bangkok	2500	1250	50%	-
Singapore	4564	4564	100%	-

*(**Source**: "Garbage Management, My Experience" by Iqbal Malik, A Vatavaran Report, 1996 and India Today, October 31, 1994 and UNEP/World Resource Institute, 1988.*

Total includes waste generated in MCD/NDMC and Delhi Cantt. Areas. It excludes the fly Ash (non-hazardour), Horticultural waste etc.)



Map -1
Waste Management Zones in Delhi

d. Quantity and Nature (Source wise) of Solid Waste in Delhi, 1996

Type	Quantity (tonnes/day)	Biodegrad -able (in %)	Recyclable (in %)	Recyclable picked by ragpickers (in %)
Residential	3560 (45.1%)	60	35	40
Markets	2040 (25.8%)	50	27	80
Hospitals & Nursing Homes	550 (6.9%)	-	6	1-2
Industrial	1080 (13.7%)	10	80	60
Railway stations	600 (7.6%)	50	48	5
Hotels & Restaurants	550 (6.9%)	50	40	10
Total	7880 (100%)			

*(**Source:** A Vatavaran NGO Report, 1996.)*

e. Garbage Generation in MCD Areas of NCT Delhi

Year	Garbage (Tonnes/day)	Silt	Total
1990-91	2505.4	280.5	2785.9
1991-92	2541.1	192.9	2734.0
1992-93	3084.1	125.0	3209.1
1993-94	3357.2	150.2	3507.4
1994-95	3617.9	302.1	3920.0
1995-96	3644.1	466.6	4110.7
1996-97	4500.7	529.3	5030.0

*(**Source** : Conservation and Sanitation Engineering Department, MCD, 1998.)*

f. Composition of Garbage in Delhi

Parameters	City wise percentage of physical constitutents: Mumbai	Calcutta	Chennai	Bangalore	Delhi
Paper & card	3.20	0.14	5.90	1.50	5.88
Metals	0.13	0.66	0.70	0.10	0.59
Glass	0.52	0.24	--	0.20	0.31
Textiles	3.26	0.28	7.07	3.10	3.56
Plastic, leather & rubber	--	1.54	--	0.90	1.46
Wood, hay, straw	17.57	--	--	0.20	0.42
Bones etc.	0.50	0.42	--	0.10	1.14
Stones etc.	--	16.56	13.74	6.90	5.98
Fine earth, ash etc.	15.45	33.58	16.35	12.00	22.95
Fermentable	59.37	46.58	56.24	76.00	57.71

*(**Source** : Solid Waste Management, Jain.)*

g. Waste Density

Country	Density (kg/cu.m)
U.S.A., Great Britain	100-150
Egypt	175-330
India-Pakistan	250-550

Density of waste is an important parameter in determining :

- Optimal fleet requirements
- Selection of vehicle technology
- Use of compactors

Density of waste in Delhi is 520 kg/cu.m.

5.0 Review of Existing Solid Waste Disposal & Management System

5.1 Administrative/Management Zones

At the Central Level, there are four Central Ministries which play a role in Delhi's solid waste management. These are

Ministry of Urban Affairs & Employment, Ministry of Environment and Forests, Ministry of Non-Conventional Energy Sources and Ministry of Health.

At the local level in NCT Delhi the areas are under jurisdiction of three local bodies Municipal Corporation Delhi (MCD), New Delhi Municipal Committee (NDMC) and Delhi Cantonment Board (Delhi Cantonment) (Refer Map 1). All three are formed under different Acts.

Jurisdiction of Various Governmental Agencies in Delhi

S.No.	Agency	Area (sq.km.)	Population (m)
1.	MCD	1397.30	8.99
(a)	Urban	599.60	8.04
(b)	Rural	797.70	0.95
2.	NDMC	42.70	0.29
3.	Delhi Cant. Board	43.00	0.09
Total	NCT, Delhi	1483.00	9.37
	Urban	685.30	8.42
	Rural	797.70	0.95

(***Source**: Dr. M.P. Mathur, National Institute of Urban Affairs, 1993.)*

The solid waste management in the respective areas are independently managed by these local bodies. The area under the jurisdiction of MCD is divided into 12 zones. The MCD is the single largest body looking after the majority of solid waste collection and disposal in Delhi. Formed under the Delhi Municipal Corporation Act, 1957, it is headed by a council comprising of a mayor and elected members. The execution powers are vested in the Municipal Commissioner. The specific responsibility of solid waste is with the Director (Conservancy and Sanitary Engineering Department) of MCD. While NDMC and Delhi Cantonment are considered separate single zones. The solid waste from major projects under development (or developed, but not transferred to MCD), is managed through private contractors by the Delhi Development Authority.

All Sanitary Landfills are also within the purview of the

Legal Acts Related to Solid Waste Management in Delhi

A.	**Municipal Solid Waste**
1)	The Delhi Municipal Corporation Act, 1957
2)	The New Delhi Municipal Corporation Act, 1994
3)	The Delhi Cantonment Act, 1994
4)	Various notifications issued from time to time such as ban on the burning of the horticulture waste
5)	The Central Pollution Control Board Guidelines, 1998 *(Action points for Managing Municipal Solid Waste)*
B.	**Hospital Waste and Industrial Waste**
1)	The Central Pollution Control Board Guidelines, 1996
2)	The Bio-Medical Waste Handling and Management Rules, 1998
3)	The Hazardous Waste (Management & Handling) Rules, 1989
4)	The Water (Prevention & Control of Pollution) Act, 1988
5)	The Air (Prevention & Control of Pollution) Act, 1987
C.	**Others**
	Environment (Protection) Act, 1986 related to A & B both.

MCD and they charge the NDMC/Delhi Cantt. Board for dumping the waste in Landfills. It is important to note that hazardous and medical waste does not come under the responsibility of the MCD and is governed by a separate set of rules.

There are also various Acts dealing with waste in NCT Delhi. Some of these are given in the box-

5.2 Components of Solid Waste Management

A. Generation & Storage
B. Collection and Transportation
C. Processing and Disposal
D. Reuse and Recycling

A clear understanding of these is necessary for a effective solid waste management.

A. Generation & Storage

The information about the quantity of waste generated is useful in evaluating the performance of existing methods and working

out future programmes i.e. new sites, transportation and disposal methods, etc. In case of Delhi, due to the practice of community bin system, it is difficult to obtain a correct idea of the quantities of waste generated. A part of the waste is recycled by the producer, some by the rag pickers and part is disposed of at places other than the community bins. Hence, the waste expected to reach the disposal site is much less than the waste normally produced (NEERI estimated about 10 per cent loss during this process).

Besides the domestic waste for which average percentages are given in Solid Waste Related Data table no. 4.0(d), the specific waste from specialised markets, industries, hospitals and such other establishments is quite heterogeneous.

a. Residential : The garbage that is generated each day in residential areas consists of rotten vegetables/fruits, kitchen waste, paper, plastic, earthenware, glass etc. In authorised colonies the civic agency (MCD, NDMC, Delhi Cantt. Board) has provided approximately three bins per colony where garbage is dumped. But in unauthorised colonies there are no bins. Here, surprisingly even in places where formal systems of garbage disposal are in place, open dumps exist. It has been observed that significent quantities of garbage remains uncollected due to various reasons. Garbage can be seen in parks, streets, on the roadside/ backlanes of residences, open drains, along railway tracks etc. (Annexure I & III).

In authorised colonies, residents employ scavengers to collect garbege waste from each house. They deposit this into nearby waste receptacle called *dhallao*. In many areas it has been observed that due to non-availability of *dhallaos*, garbage is dumped at places found convenient by the scavenger. In unauthorised colonies like Seelampur, Bhajanpura, Sonia Vihar, Sanjay Vihar, Lal kaun, Govindpuri and Seemapuri etc garbage collection is very low.

b. Market (Bazaar) Waste

i. Commercial & Wholesale Market Waste : Of the total garbage generated in Delhi every day, markets produce approxi-

mately 26% (2040 tonnes). Of this the Bio-degradables are 50% and 27% of which constitute re-cyclable waste type. The establishments producing large amounts of organic waste such as sugarcane juice and other juice shops often have no formal arrangements to dispose the waste. Another important market waste is plastic. Markets in and around Delhi have a high percentage of plastic garbage which, being non-degradable, has several negative impacts on the environment. Interestingly, of all the recyclables generated in the market 80% is picked by ragpickers.

The wholesale markets selling grains (i.e. Sadar, Pilli Kothi, Mehrauli and Dana Mandis) are located in different parts of Delhi. The garbage of these markets contains dead insects/ cockroaches, rats, cowpea, weevils etc. and is seen as road side dumps or in community bins.

The shopkeepers clean their shops and gather the dry waste outside, from where ragpickers take away the recyclables found in garbage. The rest is picked by privately employed sweepers, and taken to the municipal bin. There is a peculiar interaction of civic agency and shopkeepers in the markets. Each sweeper who is alloted an area, usually a lane, is also an employee of a municipal agency who cleans the roads and removes the garbage . He collects a daily fee from the shops and thelas *(rehdi wallahs)* for his duties. In the absence of a proper waste disposal system the shopkeepers pay these charges.

ii. Abattoir Waste : Delhi has atleast 20 markets (i.e. Sangam Vihar, Nizamuddin Market, Samay Pur, Govind Puri, Badar Pur, Harkesh Market, Gole Market, Maya Puri, Ambedkar Nagar etc.) where illegal road side slaughtering of sheep, goat, buffalos and pigs etc. takes place. What is alarming is that the conditions in these shops are worse than those in the Idgah Abattoir, which was closed under High Court orders due to unhygienic conditions. The waste generated by these slaughter markets - the cowdung and discarded carcasses is dumped in the community bins. Often rotting intestines and blood are disposed in the open sewers of the area in the absence of an adequate system of waste disposal (Annexure II).

c. Hospital Waste

Delhi has 27 major hospitals, hundreds of Nursing Homes in various residential colonies besides ESI/CGHS dispensaries, local practitioner shops and Veterinary Hospitals responsible for generating approximately 550 tonnes of this specialised garbage every day. On an average only 5-6% of this is reuseable or recyclable. Ragpickers pick only 1-2% of it.

Of the total hospital waste 47% is hazardous bio-medical waste contaminated with disease causing pathogens. The hospital waste consists of human and animal waste along with items saturated or dripping with blood and body fluids, discarded medical equipments (Injection Syringes), soiled cotton, plaster, dressing, surgical and autopsy wastes and left over food. The hospital waste requires 'incineration' or 'deep burial'. Some big hospitals have incinerators but often the staff is not equipped to handle hospital waste or the incinerator is out of order for long periods. About 70% of health care in Delhi is provided by private - nursing homes and medical practitioners. Usually, their waste is dumped in the open, near the hospitals (for example - Safdarjung Hospital), thus inviting scavengers, flies and stray cattle/dogs (Annexure II). All the waste generated (bio-medical, surgical, infectious and with potential of being reused) is disposed off in *dhaloas* or nearest municipal bins in residential areas. The waste is thoroughly over turned by rag pickers - often with bare hands and feets - to get something which could be sold.

d. Industrial Waste

Industrial Waste in Delhi is produced by a large number of legal and illegal small scale/tiny service industries (estimated to be over 1 lakh units). The waste from these is mixed with the municipal waste and is not treated. There are about 8,000-10,000 eletroplating industries and similar industries generating toxic waste, for which no proper disposal system is available. Of the total garbage generated everyday in Delhi about 1080 tonnes (approx. 14%) is industrial waste. 80% of this is recyclable or reusable, while

10% is bio-degradable. Of all the recyclables 60% are picked up by ragpickers (consisting of textile rags, cartons/corrugated sheets, packaging plastics, leather, glass, metal waste, PVC foam and rubber etc.) from the bins and rest is left scattered to be dumped at landfill sites. In the absence of specified dumping sites for industrial toxic waste indiscriminate dumping leads to ground water contamination.

e. Others

About 600 tonnes (7.5%) of the total waste generated is from the three railway stations in Delhi and 550 tonnes (7%) of total waste every day is from small and big hotels, restaurants and dhabas. 50% of this waste is bio-degradable and 40% recyclable. Apart from the waste generated in big hotels rest is dumped in open bins. In addition large quantities of fly ash (non-hazardous) from the three thermal power stations and horticultural waste (in NDMC) is generated in NCT Delhi.

B. Collection and Transportation

a. Collection of Refuse : There is no provision for household collection as the Municipal Act only provides for collection of solid waste from municipal/community bin. Over the past two years the civic agencies in selected localities have experimented with house to house collection of waste. This has not been successful due to a lack of popular cooperation. In congested areas residents show resistance when a new community bin is put near their home. Often these high population density areas are left without an adequate number of collection bins.

The community-bin system is being followed in the NCT Delhi, wherein the waste from individual premises is deposited in community-bins by the users with the help of private sweepers or domestic servants. Community bins normally consist of masonry enclosures, as well as $1m^3$ containers. Wherever the quantity of waste to be collected is large (more than 2 truck load), large enclosed structures known as dhallaos are available in different administrative zones as follows:

Distribution of Refuse Collection Facility by Administrative Zones

Sl. No.	Administrative Zones	Dustbins	Dhallaos	Open spots/ Containers
1	MCD	1,284	337	176
2	NDMC	-	900	1,000
3	Delhi Cantt.	350	-	-

(***Source** : Study of SWM in Delhi by NEERI, March 1995.)*

There are a variety of garbage bins, in terms of their capacity, shape & design. The local bin is smallest followed by dhallao, which are like rooms. The NDMC has metal bins, which can be over turned into trucks, using hydraulic tippers. It is easy to clear these metal bins unlike the masonry bins (*dhallao*) which are never cleared completely. The existing dustbins/dhallaos are depots that mainly act as transfer stations (secondary community storage bins), rather than serving people directly. Generally, persons are hired by households to collect the garbage from house to house and deposit it in the specified municipal collection points. The supervision of these collection points as well as their design has scope for further improvement specially in terms of location and aesthetics. In many places, the receptacles do not have doors and mesh cover. Inadequate collection of waste by municipal agencies results in insanitary conditions around the dustbins/ dhallaos due to invasion of stray animals/rag pickers. Casual dumping of waste along the road sides/open drains and depressions near slum and JJ clusters is a common feature.

The civic agencies (MCD, NDMC & Delhi Cantt. Board) have above 40,000 Safai Karamcharies on roll, but work ethics are poor and absenteeism or false attendance is common. Each community storage bin has the name of the sanitary inspector and safai karamcharies on duty on it but the response to public complaints is poor.

b. Transportation of Waste : The waste from the community bins is collected and transported to the processing and disposal sites, using a variety of vehicles owned by MCD, NDMC and Cantonment Board. MCD has about 615 vehicles

including tippers, dumped places and compactors; whereas NDMC has 41 (22 compactors and 19 mini compactors) vehicles and the Cantonment Board has 8 general performance open body trucks, employed for this purpose. Animal carts are also used in MCD areas (namely, Shahdara) for transportation of the garbage to the landfill sites. In general, it is noted that the present transportation system of waste has following weaknesses:

i. Daily lifting of garbage from all the *dhallao*/dustbin is not always practised. When lifting is done from such recep tacles the entire area stinks.

ii. Often garbage trucks are not properly covered and are poorly maintained.

iii. Lifting of garbage from *dhallaos*/dustbins is done manually and the waste around these collection sites is generally not completely lifted. The maintenance of the dustbins/dhallaos is also poor.

iv. The capacity of the truck is often not fully utilised and there is a scope for route-optimisation.

v. On Sundays and public holidays the lifting of garbage is often reduced to half.

C. Disposal and Processing of Waste

The solid waste collected by MCD, NDMC and Cantonment Board is mostly disposed of in low-lying areas at the landfill sites (SLF), where it is covered with soil and debris, etc.

a. Landfill Sites : Since the 1950s over 12 large landfills have been packed with all sorts of non biodegradable and toxic wastes of Delhi (Map No. 2). The area thus covered is at least 1% of Delhi's total area. The present landfill operations following conventional ways of dumping the refuse create pollution. None of the existing landfills initially had any environment impact assessment done. NEERI in its Phase I report, (1996) states as follows:

> "The examination of water environment indicates high total dissolved solids concentration in contiguous ground water sources. Solid waste samples from the various depths of the landfills contain, high values of faecal coliforms and faecal streptococci. Thus, the air, water and land components of environment at the landfill sites in Delhi are grossly polluted".

On these landfill site vultures, cows, pigs, dogs and rag pickers are a common sight. None of the existing landfill's base and sides are lined, due to which there is a continuous threat of ground water contamination.

The details of Sanitary Landfill sites are given as follows:

Details of Existing Sanitary Landfill Sites in Delhi

SLF site	Year of operation	Expected life garbage filled	Area up to (Ha.)	Quantity of covered every day (T/d)
MCD				
Bhalaswa	1992	1997-98	16.0	1,800
Gazipur	1984	2004	28.0	1,300
Okhla	1994	1997-98	7.2	800
NDMC				
Gazipur	1984	2004	-	245

(Source : NEERI Report, 1995)

A statement given below indicates the zones/areas which transport the garbage to the three landfill sites:

Gazipur	Bhalswa	Okhla
Shahdara (South & North)	Civil line zone	South zone
Partly city zone	Rohini Zone	Central Zone
Sadar-Paharganj Sone	Najafgarh zone	DDA areas
Partly Central Zone	West Zone	
New Delhi Municipal Council	Narela Zone	
Slaughter House Waste	Karol Bagh Zone	
ITPO, Pragati Maidan	Partly from Sadar	
APMC	Paharganj Zone	
Mother Dairy	Partly from City Zone	

(Source : First Inspection Report on Collection, Transportation and Disposal of Solid Waste in Delhi submitted by CPCB, 1998 in pursuance of Supreme Court order dated 23/1/98 in W.P(C) 286/94).

It is generally noted that at the landfill sites a proper and scientific method of disposal is not adopted. Sites are not prepared before using them for waste disposal and lack of underground drainage and the collection and treatment of liquid waste.

Besides the SLF sites given in table 4 above, following six new SLF sites have been approved by the DDA/MCD for future solid weste disposal-.

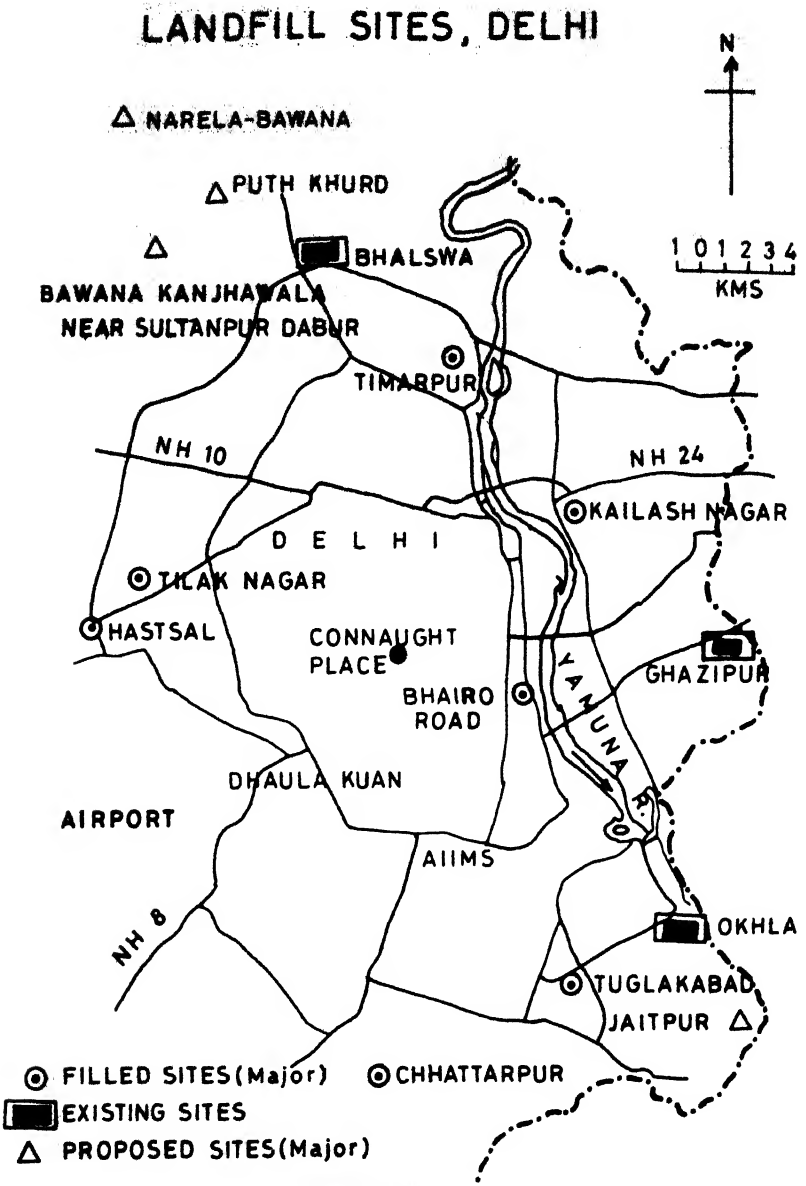
a.	Narela-Bawana	60.0 Ha
b.	Bawana-Kanjawala (near Sultanpur-Dalbas)	40.0 Ha
c.	Deorala	4.8 Ha
d.	Kair	4.0 Ha
e.	Puth Khurd	56.0 Ha
f.	Jaitpur mines	9.8 Ha

b. Composting : Composting of city garbage can produce good quality organic manure and soil conditioner at a cost which is cheaper than artificial fertilizers. At the moment there are two mechanical compost plants one each of MCD and NDMC. Their capacities and other details are given below :

	NDMC Plant	**MCD Plant**
Location	Near STP Okhla	Near STP Okhla
Date of Start	1985	1980
Capacity	200 tonnes/day	150 tonnes/day

It is noted that while the NDMC plant is in operation, there are problems with the working of MCD plant though it has been revived due to court pressure. This problem is mainly attributed to the improper screening of waste in terms of its organic content.

c. Incineration and Power Generation Plant : A 300 mt/day incineration-cum-power generation plant to produce 3.7 MW power was set up near Timarpur in 1989 with assistance from DANIDA. The plant was operational only for a very short time. It was found that the calorific value of the solid waste assumed in the design was


LANDFILL SITES, DELHI
N
NARELA-BAWANA
PUTH KHURD
BHALSWA
BAWANA KANJHAWALA
NEAR SULTANPUR DABUR
1 0 1 2 3 4
KMS
TIMARPUR
NH 10
NH 24
KAILASH NAGAR
D E L H I
TILAK NAGAR
HASTSAL
CONNAUGHT PLACE
BHAIRO ROAD
YAMUNA R.
GHAZIPUR
DHAULA KUAN
AIRPORT
AIIMS
NH 8
OKHLA
TUGLAKABAD
JAITPUR
FILLED SITES(Major)
CHHATTARPUR
EXISTING SITES
PROPOSED SITES(Major)

MAP-2

1465 kcal/kg as compared to the 662-721 kcal/kg, observed during the test run. Hence steam generation and subsequent power generation was not feasible. Besides density and percentage of ash in the waste was also higher.

D. Reuse and Recycling

Recycling of solid waste takes place mostly in the informal sector. Delhi has almost 1 lac ragpickers, scavenging the urban waste for refuse that can be sold to middlemen or kabaris. However, as both the trade and actual reprocessing is carried in the informal sector, it is difficult to estimate their exact contributions. Infact their vital work is not yet recognised in overall solid waste management practice and they are harassed by civic agencies, police and lack institutional support.

5.3 Critical Aspects of Environmental Concern in Solid Waste Disposal and Management

i. Water Pollution : Water quality has declined due to lack of proper system of solid waste management **(a)** contamination of ground water resources due to leachate **(b)** changes in physico chemical quality of surface water due to surface run-off **(c)** contamination of surface and ground water with pathoganic organism carried over by surface run-off **(d)** contamination of ground water with heavy metals such as lead, chromium and cadmium. All the water samples tested were bacterialogically contaminated.

ii. Land Pollution : It is noticed that physical and chemical properties of soil are affected due to dumping of solid waste. In the past landfills that have been filled with all sorts of non-biodegradable and toxic wastes cover approximate 1% of Delhi's land mass. The SLF site at Bhalswa, Gazipur and Okhla revealed presence of copper, manganese, iron and zinc in significant amounts. The leachate in these sites was found rich in chromium, lead, iron, nickel and zinc and was dark brown and blackish in colour with foul smell. In general, total coliform, faecal coliforms and faecal streptecocci were detected in all the SLF samples upto 7 mt. Depth. The cellulose content and

cellulose to lagnine (C/L) ratio decreased during degradation. Bio gas generated during anaerobic decomposition of waste from SLF sites can be recovered for local use.

iii. Air Pollution : Spontaneous burning of solid waste emits suspended particulate material (SPM), CO_2, SO_2 & Mox. The Bio chemical degradation results in generation of methane, hydro-sulfide and amonia. The presence of air borne pesticides is also noticed around the landfill sites. The SLF site of Gazipur has revealed high levels of NH_3, whereas SPM levels were extremely high in all the SLF sites compared with CPCB standards. Aerobiological studies revealed high density of micro-organism around 1/2 KM downwords of SLF sites.

iv. River Pollution : Three power stations located along the river Yamuna in Delhi generate about 5600 m.t. fly ash every day and, except for very little (100 m.t. per day) supplied to the cement grinding unit through Cement Corporation of India (CCI), most of it finds its way to the banks of the river causing severe pollution. During hot summers this light weight material impedes the smooth flow of traffic in the surrounding areas.

v. Others : *Hazardous and Infectious Hospital wastes :* Delhi's 80 hospitals and approx. 400 private nursing homes produce hazardous and highly infectious waste that gets mixed with other domestic waste. Municipal workers handling the waste and the ragpickers are at risk. A survey done in Delhi revealed that 66% of the ragpickers who worked in bins containing hospital wastes had high rates of skin problems. respiratory allergy and gastro intestinal infections.

Industrial Toxic Wastes : The handling of industrial toxic waste is beyond the MCD's operations, but it has nevertheless been entrusted with the task . Indiscriminate dumping of such waste leads to ground water pollution and other environmental problems e.g. lead poisoning, respiratory diseases etc.

Plastics : Large scale and irresponsible use and disposal of polythene bags has created an enormous environmental and health hazard. It is estimated that in Delhi about 300,000 polythene bags are

discarded daily. Of these, a sizeable number end up choking drains, sewers and even killing stray animals. In rainy season these block the drain and cause water logging. These plastic bags made of recycled plastic waste are burnt and in the process noxious fumes are emitted.

6.0 Issues and Recommendations

In Delhi, with the combined efforts of MCD, NDMC, Cantonment Board, etc., about 7880 tonnes of waste is handled and it is likely that this quantity may go up to about 10,000 tones per day by the year 2001. It is also true that besides municipal handling of waste, part of the waste is casually dumped along roadsides and other natural depressions by private contractors. Analysis of the whole process of waste consideration while formulating future planning strategies for better quality of life in the National Capital Territory of Delhi, some of these are described in the following sections.

Public Participation

Since garbage management is a public issue the system adopted by the local bodies should be acceptable to it. All local bodies must make use of public views in the process of waste management. Public awareness programmes, also through the media, have found success in many developing countries. In Kathmandu, it helped in increasing public participation in a special campaign to clean up the house-to-house courtyard. In New Zealand NGOs have taken up the campaign to solve waste problems by promoting use of refillable containers. In India, in certain cities, the involvement of NGOs, CGOs and co-operatives has helped waste management. In Delhi specific programmes for involvement of the private sector, co-operatives and NGOs in better waste management could be worked out by the local bodies.

Inter-agency Co-ordination and Advance Planning

For effective waste management the efforts of local bodies and their departments involved need to be integrated. These include DDA, DPCC, GNCT, Delhi (Development Commissioner), Urban

Development (Land & Building) MCD (Conservancy and Sanitation Engineering, Slum Wing, Health), NDMC (Health, Civil Engg.) Ground Water Board, Delhi Cantt. Board etc. The location of dustbins/ dhallaos in required number must form part of layout plans of all residential, commercial, industrial and institutional schemes. The sites for SLF, compost plant, transfer stations, zonal workshops and parking etc., should be identified with the help of all the concerned agencies in advance. The filled up sites should be handed back to the Horticulture Deptt. of MCD, NDMC, DDA, etc., for development as city/district parks, parking lots and such other uses.

Arrangements for Handling of Specialised Wastes

Separate arrangements for lifting, transportation, treatment and disposal of waste produced from hospitals, nursing homes (NH), slaughter-house, subzi mandis and other specialised markets, industries etc., are required to prevent their adverse environmental impacts. To handle these specialised wastes the construction of incinerators on pay-and-use basis, modern abattoir, and a safe site for disposal of hazardous waste is required at an appropriate location. Construction of the biogas plants for handling of agro-wastes of rural areas also requires special efforts.

Energy Recovery

Energy recovery techniques from waste are gaining significance both in the developed and developing countries. Depending upon the disposal techniques adopted, energy in the form of gas, electricity and fuel-cakes, can be recovered from waste. Experiments of collecting gas from SLF sites in Delhi are being worked out for their wider use. Such initiatives need encouragement.

Improvements in Landfill Methods

Improvements in the crude dumping of waste in selected dug-up lands are required due to form environmental considerations. These include preparation of SLF sites, designing of underground drainage and its treatment system, use of modern

equipment on the sites to minimise human handling, use of inert material as cover-up layers and spraying of insecticides.

Organised Collection of Waste from Marginal Areas

Improvements are urgently required for speedy collection and transfer of waste produced from marginal areas i.e. JJ clusters, slum areas, unauthorised colonies, and urban villages. These areas require greater supervision and monitoring by the municipal agencies.

Modifications in Legislative Framework

While solid waste management is the responsibility of local authorities, alone they have been unsuccessful in handling the waste property. There is a need for involvement of the CBOs, co-operatives and the public in general in waste disposal. The executive must recognise and facilitate this. Further more penalties for casual dumping of waste need to be made more effective with wide publicity and warning.

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References/Bibliography

1. Agarwal Ravi & Chaturvedi Bharati, Paper - Solid Waste Disposal and Recycling in Delhi - A Case Study. Waste Disposal in Engi neered Landfills (1991), Manoj Datta (Edit).
2. CPCB & DPCC (1996). Report on Collection, Transportation and Disposal of Municipal Solid Waste in Delhi, Aug.
3. CPCB (1998) Action Points for managing Municipal Solid Waste (MSW), Delhi.
4. DDA, Master Plan for Delhi - 1962, New Delhi.
5. DDA, Master Plan for Delhi Perspective 2001, New Delhi.
6. HSMI (HUDCO) & IHUDS, Problems and Issues in Urban Environmen tal Management - Experiences of Ten Best Practices - A Report.
7. IES (1996). Proceedings of the Conference on Environmental Man agement, Sept.', New Delhi.
8. Jagmohan Committee Report (1995) on Delhi's Sanitation and Con - nected Matters, New Delhi.
9. Malik Iqbal (Dr.), Garbage Management My Experience - A unpub- lished "Vatavaran" Report (1996), New Delhi.
10. Mathur M.P., Solid Waste Management - A case Study on Delhi, National Institute of Urban Affairs, New Delhi.
11. Ministry of Environment and Forest (Hazardous Substances Manag- ement Division), Background Material of Training Workshop on Urban Solid Waste Management (1993), New Delhi.
12. NEERI (1982). Existing Facilities of Solid Waste Disposal in Delhi & Planning up to 2001. Part I & II, DDA.
13. NEERI (1995). Study of Solid Waste Management in Delhi, DDA.
14. Parvesh Newsletter (June, 1997), World Environment Day. Spl. Issue on Municipal Solid Wastes (Garbage). Central Pollution Control Board, Delhi.
15. PHDCCI (1996) & Govt. of NCT Delhi, Background Paper of the Seminar, "Delhi Vision 2010 : Civic Infrastructure and Environ- ment", New Delhi.
16. Report of the High Powered Committee on, Comprehensive Action Plan on Environment and Pollution Control in Delhi (Aug., 1994).

17. Srinivas D.S.R.K., Managing Urban Environment - A Case of Delhi. ITPI Journal, March-June, 1995.

18. Tata Energy Research Institute (1995), "State of Delhi's is Environment", New Delhi.

19. Voluntary Health Association of India (1993), "A Tale of Two Cities", New Delhi.

20. Writ Petition (C) No. 286 of 1994, Dr. B.L. Wadhera Vs Union of India - Judgement dated 1/3/96 on Solid Waste Related Matters of NCT Delhi.

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Annexures

Annexure -I

MCD Areas

Sl. No	Zone	Name of the Prominent Places where Open Dumping of Garbage was seen	Name of Colonies, JJ Clusters, Societies where Insanitary Conditions Exist
1.	Central	Parks/Drains at Sidharth Basti & Sunlight Colony, Drain behind Sidharth Ext. Flats and near Nizamuddin Rly Station, Open plot/road side/parks at Sarita Vihar Drain at Defence Colony, Drain/open land, Sriniwaspuri , Roads at Govindpuri Market, Open Dumping at Telephone Exchange, Sarita Vihar	Easst of Kailash, Garhi, Okhla Subzi Mandi, Bharat Nagar, Sarita Vihar, Back Side of Arawali Apartments, Opp. Kalka Public School, Sunlight Colony I & II, Jamia Nagar, Jakir Nagar, Alinganj, Pillanji.
2.	Civil Lines	Hamilton Road, Pul Bangesh, Backside of Tis Hazari Court, Bal Shishu Vatika, Lal bagh, Side Lane Ring Road (Near Azadpur & Bharola Village), Industrial waste dumping on drain in Wazirpur Indl. Area, Drains at Lal Bagh Drains/Parks/Vacant Land at Jahangirpur, Drain at Indira Vikas Colony (opp. Nirankari Colony), Drain near G.T. Karnal Road, Park/Vacant Land, Kabir Basti, Ghantaghar, Roshanara Road	Nehri Vihar, Near Calcutta Gate (Near Hanuman Temple), Near Derawal Town Market, Lal Bagh Colony, Nirankari Colony (Indira Vikas Colony), Jahangirpuri., Sangam Park, Timarpur (JJ Clusters & Commercial Place)

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S. No.	Zone	Name of the Prominent Places where Open Dumping of Garbage was seen	Name of Colonies, JJ Clusters, Societies where Insanitary Conditions Exist
3.	Shahdara (N)	Shastri Park, Bhajanpura, Sunder Nagri, Seemapuri, Seelampur, Zafarabad etc	Seelampur, Seemapuri, Janta Mazdoor Colony, Sunder Nagri, Zafarabad etc.
4.	Narela	All Villages in Zone including Narela & Alipur Town	Dairy operation seen in all Villages
5.	Shahdara (S)	Drain passing through Mayur Vihar, Phase I (Noida-Delhi Border), Market Near Nirman Sanchalan Apptt Mayur Vihar, Phase I, Pond near the Patparganj, Post Office JJ Cluster, Sasi Garden Sarai (East Nizamuddin), Parks/Open Grounds at Trilokpuri & Kalyanpuri, Drain passing through Geeta Colony, Block-5 Sanjay lake, Park Kotla, Main Road, Pond near Kakarwal, JJ Cluster Vacant Land, Backside Shivam Enclave, Near Surajmal Park	JJ cluster, Sasi Garden, JJ cluster, Kalyanpur Near Janta Flats, Trilokpuri, Kalender Colony, Dilshad Garden, JJ cluster, Sasi Garden
6.	City	Drain passing through Nizamuddin-Jungpura, Parks in East Nizamuddin, Gautampur, Dhobi Ghat - SA Colony, Bengali Basti	JJ cluster, Bura Sarai (East Nizamuddin), Near Dispensary, Bura Sarai (East Nizamuddin)

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S. No	Zone	Name of the Prominent Places where Open Dumping of Garbage was seen	Name of Colonies, JJ Clusters, Societies where Insanitary Conditions Exist
7.	Sadar Paharganj	Main Road, . J Cluster, Motia Khan Gulabi Bagh near Super Bazar	JJ cluster, Motia Khan, Qutab Road, In the surrounding of dhallao at Motia Khan, Chitragupta Road
8.	West	Behind Shadley Public School (Mayapuri), Mayapuri Enclave(Hari Nagar), Mayapuri Drain, Keshavpuram Park & Lane, Khayala, Ramesh Nagar Drain Najafgarh Drain, Vikaspuri, Vikas Kunj, Pankha Road	Maya Enclave (Hari Nagar), Raghuvir Nagar, Singhalpur Village (Shalimar Bagh), Vikaspuri Traffic Light, Keshavapuram , Subhash Nagar –13 Block, Khayala, Lakkar Mandi, Basai Darapur
9.	Rohini	Ritu Aptt. (Paschim Vihar), Mahindra park (Lok Vihar), Opensite (Behind T.V. Tower)	Opp. Sunshine Appt. (Paschim Vihar)
10.	Najafgarh Nangloi	Mangolpuri, Sultanpuri, Palam Village, Mahipalpur,	Mangolpuri, Sultanpur, Nangloi

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S. No	Zone	Name of the Prominent Places where Open Dumping of Garbage was seen	Name of Colonies, JJ Clusters, Societies where Insanitary Conditions Exist
11.	Karol Bagh	Open plot on Pusa Road, Park in Prem Nagar, Nehru Nagar along Railway Track, Under Shadipur Depot Flyover	
12.	South Zone	In open drains of Dakshinpuri, Open plot in Khirki Village, Park of Khirki Village, Open plot near Shamshan Ghat, Begumpur, On Road of Savitri Nagar	Dakshinpuri, Madangir, Khanpur, Shahpur Jat Munirka Village

*(**Source** : CPCB, 1998 First Inspection Report submitted in HC.)*

S. NO.	Zone	Places where Dairy Operations Seen and Causing Unhygienic Conditions	Places where Construction Material and Demolition Debris Seen Causing Problems
1.	Central	Behind Sidharth Ext. Flats, Sarita Vihar, Madanpur, Khadar, Aliganj, Pillanji, Nehru Nagar	Horticulture waste seen in Government Colonies
2.	Civil Lines	New Chandrawal (Near Jawahar Nagar), Old Chandrawal, Village Malikpur, Munshi Ram Dairy (West Mukherjee Nagar), Adarsh Nagar	
3.	Shahdara (N)	Janta Mzdoor Colony, Sunder Nagari	
4.	Shahdara (S)	DDA Land near UNA Apartment, Mayur Vihar, Phase I, and Gazipur	Park Near Sulabh Shochalaya and Mayur Public School
5.	West	Subhash Nagar-12 Block and Keshavpuram, Ramesh Nagar and Raghubir Nagar	Kotla Lane (Dhallao) in the surrounding
6.	Rohini	Imahindra Park (Near Lok Vihar)	Subhash Nagar-13 Block, Punjabi Bagh, Paschim Vihar and Basai Darapur,
7.	Najafgarh	Palam Village	Mahipalpur
8.	Karol Bagh	Bagh Kare Khan (Kishanganj)	Pyarelal Road Crossing, Ellahi Box Road, Backside 9/15, East Patel Nagar.
9.	South		Khirki Extension

S. NO.	Zone	Places/Areas where Slaughter Waste was seen	Receptacles where Hospital Waste was seen
1.	Central	INA Market (Near Super Bazar) and Dhobi Ghat (Lodhi Road)	INA Market (Near Super Bazar) and Dhobi Ghat (Lodhi Road)
2.	Civil Lines	Sangam Park, Bharoal village (Ring Road)	Opp. Stephen Hospital, Near Malaria Office (Under Hill Road), Nirmala Hridays Hospital (Outer Ring Road) and Back side Bara Hindu Rao
3.	Shahdara (N)	Dhallao at Ghonda More, Seelampur	
4.	Shadara (S)		DB near the Yasudha Nursing Home, Patparganj
5.	City	Dhallao at Machhi Market, (Near Jagar Cinema) and at Rakabganj	Dhallao, LNJP Hospital, Dhallao, Backside LNJ Hos. Dustbin MAM College Dhallao, Sheroff Eye Hosptl.
6.	Sadar Paharganj	Dhallao, backside of slaugher house	
7.	West	Raghubir Nagar	Behind ESI Hospital (Raja Garden), DDU Hospital (Hari Nagar), Basai Darapur and Punjabi Bagh
8.	South	Nanakpura	

Annexure-II

NDMC Areas

S.No.	Circle	Name of the Prominent Places Where Open Dumping of Garbage was seen	Name of Colonies, JJ cluster, Societies Where Insanitary Conditions Exist
1.	C.NO.2, 12, 13	Road at CPWD colonies at Gole Market,Punchkuiya Road, Netaji Nagar Colonies, INA Market Pillanji Village (Near Laxmi Bai Nagar, Mochi Village (Near Mubarka pur), A.R. Dainy	CPWD colonies at Gole Market Punchkuiya Road, Harijan Basti, Netaji Nagar (JJ Cluster)
2.	C.No.3	Backlane of Delhi Emporium : Garbage is collected outside the trolleys along with road side, it is segregation point for ragpickers	Raja Bazar Udyan marg (JJ Cluster)
3.	C.No.4	Near Bus Stand, Pt. Pant Marg, Inside Pake Lane, Talkatora Indoor Stadium	Inside Shastri Bhawan Dustbin No. 7, Inside President House
4.	C.No.9	JJ Cluster, Tuglak Land, Backlane Kothies of Johar Bagh Amrit Shergil lane (inside park)	JJ Cluster, Tughlak Lane Race Course Cinema, Race Course Mess
5.	C.No.5	Inner Lanes of the Most of the Circle	Hyderabad House, Hailey Road

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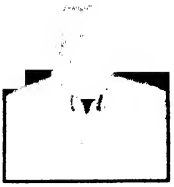
S.No.	Circle	Name of the Prominent Places Where Open Dumping of Garbage was seen	Name of Colonies, JJ cluster, Societies Where Insanitary Conditions Exist
6.	C.No. 6		Ravindra Nagar, Pandara Road, Bapa nagar
7.	C.No. 8	Drain in Lodhi Colony Inner Lane in Bharti Nagar	Lodhi Colony

Authors



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